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13th

EIGHTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

Mass.; Agricultural experiment station, A.

1895-1900

JANUARY, 1896.

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REPORT.

It is proper, in making this first report of the Hatch Experiment Station since its consolidation with the State Experiment Station, that its history and organization should be briefly outlined and made a matter of permanent record. The State station was established by act of the Legislature in 1882, with Prof. Charles A. Goessmann as director. Though located on the college grounds and making use of its land for purposes of experiment, it had no direct connection with it, but was governed by its own board of control. Up to the time of consolidation twelve annual reports had been issued and fifty-seven bulletins.

The Hatch Experiment Station was established under act of Congress, Public No. 112, Feb. 25, 1887. The provisions of this act were accepted by the General Court, chapter 112 of the Acts and Resolves of 1887. At a meeting of the trustees of the Massachusetts Agricultural College, held March 2, 1888, it was voted to establish another department, to be styled "The Experiment Department of the Massachusetts Agricultural College." The name was subsequently changed to the Hatch Experiment Station of the Massachusetts Agricultural College, and Pres. H. H. Goodell was elected director. Five thousand dollars of its income were annually paid over to the State Experiment Station, in consideration of its performing the chemical work required. Previous to consolidation there had been issued seven annual reports, thirty general, three special and seventy-eight meteorological bulletins.

For several years a growing feeling had manifested itself that the two stations should be united, in the interest of economy of administration, work and result.

In 1894 an act was passed by the General Court, chapter 143, to consolidate the Massachusetts Agricultural Experiment Station with the Experiment Department of the Massachusetts Agricultural College. Owing to a trifling error, the

consolidation could not be effected, and the act was amended, chapter 57 of the Acts and Resolves of 1895. The full text, as amended, is as follows: —

SECTION 1. The Massachusetts agricultural experiment station, located at the Massachusetts agricultural college in Amherst, may be transferred to and consolidated with the experiment department of the said college now known as the Hatch experiment station, in the manner hereinafter provided.

SECT. 2. The said Massachusetts agricultural experiment station, at any meeting duly called for such purpose, may, by a vote of two-thirds of the members present, authorize the transfer of all the rights, leases, contracts and property, of every kind and nature, of said station to the Massachusetts agricultural college; and the trustees of said college may, at any meeting duly called for such purpose, accept the same for said college in behalf of the Commonwealth, whereupon such transfer shall be made by suitable conveyance; and when such transfer shall be made, the said Massachusetts agricultural experiment station shall be deemed to be a part of, and to belong to, the experiment department of said college, under such name as said trustees may designate.

SECT. 3. The trustees of said college shall thereafter continue to carry on the experimental and other work for which the Massachusetts station was established, and to administer and apply all the property and funds that may be received by them hereunder, and by virtue hereof, for such purposes. They shall also from time to time print and publish bulletins containing the results of any experimental work and investigations, and distribute the same to such residents and newspapers of the Commonwealth as may apply therefor.

SECT. 4. Nothing herein contained shall operate to affect or discontinue the annual appropriations and payments thereof made and to be made by the Commonwealth for the proper maintenance of experimental work, under section six of chapter two hundred and twelve of the acts of the year eighteen hundred and eighty-two and section one of chapter three hundred and twenty-seven of the acts of the year eighteen hundred and eighty-five; and the payment of said appropriations shall hereafter be made to the treasurer of the Massachusetts agricultural college. The trustees of said college shall make or cause to be made annually to the general court a detailed report of the expenditure of all such moneys, and such further report of the annual work of the experiment department of the college station as the trustees of the college shall deem advisable.

In accordance with this action of the Legislature, at a special meeting of the trustees, held April 16, 1895, it was voted to accept, for the Massachusetts Agricultural College, the transfer of all the rights, leases, contracts and property of every kind and nature of the Massachusetts Agricultural Experiment Station to the Massachusetts Agricultural College. It was voted to consolidate the two stations, under the name of the Hatch Experiment Station of the Massachusetts Agricultural College, and the following organization was adopted: —

Henry H. Goodell, LL.D., . . .	*Director.*
William P. Brooks, B.Sc., . . .	*Agriculturist.*
George E. Stone, Ph.D., ...	*Botanist.*
Charles A. Goessmann, Ph.D., LL D., .	*Chemist* (fertilizers.)
Joseph B. Lindsey, Ph D., . . .	*Chemist* (foods and feeding.)
Charles H. Fernald, Ph.D., . . .	*Entomologist.*
Samuel T. Maynard, B.Sc., . . .	*Horticulturist.*
Leonard Metcalf, B.S., ...	*Meteorologist.*
Henry M. Thomson, B.Sc., . . .	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc., ...	*Assistant Botanist.*
Henri D. Haskins, B.Sc., . . .	*Assistant Chemist* (fertilizers).
Robert H. Smith, B.Sc., ...	*Assistant Chemist* (fertilizers).
Charles S. Crocker, B Sc., . . .	*Assistant Chemist* (foods and feeding).
Edward B. Holland, B.Sc., . . .	*Assistant Chemist* (foods and feeding).
Robert A. Cooley, B.Sc., . . .	*Assistant Entomologist.*
Joseph H. Putnam, B.Sc., . . .	*Assistant Horticulturist.*
George A. Billings, B.Sc., . . .	*Assistant in Foods and Feeding.*
Charles A. King, ...	*Observer.*

ANNUAL STATEMENT

Of the Hatch Fund of the Massachusetts Agricultural College for the Year ending June 30, 1895.

By George F. Mills, *Treasurer pro tem.*

Cash received from United States treasurer,		$15,000 00
Cash received from agricultural department,		861 14
		$15,861 14
Cash paid for salaries,	$8,382 72	
Cash paid for labor,	1,592 88	
Cash paid for publications,	1,476 16	
Cash paid for freight and express,	103 53	
Cash paid for postage and stationery,	51 41	
Cash paid for heat, light and water,	101 90	
Cash paid for chemical supplies,	479 60	
Cash paid for seeds, plants and sundry supplies,	500 71	
Cash paid for fertilizers,	344 08	
Cash paid for feeding stuffs,	373 52	
Cash paid for library,	528 23	
Cash paid for tools, implements and machinery,	867 27	
Cash paid for furniture,	50 92	
Cash paid for scientific apparatus,	534 56	
Cash paid for travelling expenses,	195 37	
Cash paid for contingent expenses,	96 42	
Cash paid for building and repairs,	181 86	
		$15,861 14

Amherst, Mass., Sept. 20, 1895.

I, the undersigned, duly appointed auditor, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1895; that I have found the books well kept, and the accounts correctly classified as above, and that the receipts for the time named are shown to be $15,861.14, and the corresponding disbursements $15,861.14. All the proper vouchers are on file, and have been by me examined and found to be correct, there being no balance to be accounted for in the fiscal year ending June 30, 1895.

CHARLES A. GLEASON,
Auditor.

REPORT OF THE BOTANIST.

GEORGE E. STONE.

This department of investigation was established in 1888 and continued until 1892, when, on account of Dr. Humphrey's resignation, it was temporarily discontinued. Last July the department was re-established, and the physiological laboratory is now devoted to experimental work along the lines for which it was largely designed. Owing to the fact that the laboratory and its equipment were being used in other lines of investigation to the middle of September, experimental work in botany was necessarily delayed, and it was not until October that experiments were under way. At the present time, therefore, only a brief report can be offered. It may not be out of place, however, to state concisely some of the details relating to the line of work which is being pursued, reserving a fuller account of the experiments for subsequent publications.

The work of the division falls mainly under two heads, namely, vegetable physiology and vegetable pathology. The first occupies itself with a study of plant diseases, their prevention and cure. The second deals particularly with the function of the plant, whether normal or abnormal, and is concerned with the action of such external influences as heat, light, moisture, etc. It further endeavors to ascertain how far the utilization of these external influences is responsible for the inroads of fungi, and how far the fungi can be controlled by these physiological factors.

Study of Injurious Fungi.

Throughout the entire year a large number of diseased plants is sent in for diagnosis. Work in this line must always be in progress, and the examination of these dis-

eased forms occupies considerable time. Very frequently some of the diseases prove to be new, or at least little understood, and a study of them must be made for the purpose of gaining an accurate knowledge of their characteristics and habits, and thus enable us to treat them in an intelligent manner. It is highly important that the nature of every plant disease be fully understood before any attempt is made to treat it. Any attempt at treatment not based on knowledge is as unscientific as it is impracticable. Among the apparently new diseases occupying our attention at present are bacterial diseases of the strawberry and orchid, a begonia leaf disease, a stem disease of the cultivated aster and a rust on the blackberry. Besides these, observations are being made on a number of other more or less known fungi.

In connection with the study of injurious fungi, numerous tests are being made with new fungicides, especially with solutions which can be used in the greenhouse. These tests are first made directly on the spores in the laboratory, and then the solutions are applied to susceptible or diseased plants in the greenhouse. By means of such tests the effects of the solution on the spores can be readily observed, and the strength of the solution required for spraying can be tolerably well determined.

Nematode Worms.

No class of plants is more frequently sent in during the winter than greenhouse cucumbers affected with these worms, which completely riddle the tender tissues of the roots, much to the detriment of the plants. No satisfactory remedy has as yet been found, though various experiments are now being made in the greenhouse for the purpose of relieving the market gardener from these pests.

Beneficial Fungi (*Mycorhiza*).

It has been known in Europe for some years that the roots of many plants are covered with fungous growths, the predominance of which — in some instances, at least — is believed to have some bearing on the absence of root

hairs. These facts, with other phenomena apparently of a similar nature which occur in the leguminosæ, etc., have led Frank * to surmise that these fungi play an important role in the assimilation of food material from the soil. As no investigations have been made to our knowledge on the occurrence of fungi on the roots of our native species of plants, Professor Smith and myself have devoted considerable attention during the past summer to work in this direction, for the purpose of determining, first, the prevalence of fungi on roots of our native plants; second, their nature and distribution; third, their relation to the absence of root hairs. Already a large number of plants have been examined, and it is proposed to carry on the investigations during the coming summer, with these additional points in view, — fourth, to prove by means of cultures whether the fungi are really essential to the plant in the assimilation of food from the soil; fifth, if proved, to throw some light, if possible, upon the process of assimilation; sixth, to ascertain whether these fungi are in any way — as Kerner maintains they are — accountable for the difficulty of transplanting certain plants.

Damping Fungi and their Relations to Temperature and Moisture.

Experiments are being made to ascertain the exact relations of the development of the damping fungi to temperature and moisture conditions. A large number of plants subject to damping off are being experimented with in a portion of the greenhouse provided with self-registering instruments. In connection with this line of work, experiments are being made to find out at what temperature the spores of injurious fungi common to the greenhouse commence to germinate. These experiments are undertaken for the purpose of learning to what extent certain diseases can be controlled by temperature and moisture conditions.

* Lehrbuch der Botanik, page 295.

General Botanical Work.

Grass Collection.

Among the specimens sent in by farmers and other citizens of the State for determination are not infrequently grasses. The station possesses already a small collection of these most important plants, and it is hoped that in the course of time a representative of every species peculiar to Massachusetts will be found here, not only for our own use in aiding identification of obscure species, but for the benefit of the student and visitor who may wish to become familiar with them.

Weed Collection.

Any one who is conversant with our ever-extending commercial relations with foreign countries can realize that a considerable number of new species of plants reaches us every year. That most of these may prove perfectly harmless there can be no doubt; but, on the other hand, we do not know but that there is in our State to-day some slumbering pest, some unnaturalized immigrant, which may in a few years become as common as the daisy or shepherd's purse, and prove as disastrous as the Russian thistle. For this reason we wish to extend our collection of State weeds, and keep a careful record of the nature and time of introduction of every species. This department, therefore, requests the co-operation of all those interested in such matters, in its endeavor to make a complete collection and accumulate data bearing on the habits of our weeds.

REPORT OF THE AGRICULTURIST.

WILLIAM P. BROOKS.

Leading Results and Conclusions based upon the Experiments outlined in the Report of the Agriculturist.

Grass and Clover.

1. Nitrate of soda applied in early spring may safely be depended upon to produce a profitable increase in the first crop of hay, but such application will not materially increase the yield of rowen. The amount to be used is from 150 to 200 pounds per acre.

2. Muriate of potash applied to land which is to be seeded to mixed grasses and clovers may be depended upon to increase the proportion of clover in the produce, and consequently to make the hay more highly nitrogenous, and particularly to increase the yield of rowen. The amount needed is about 175 to 200 pounds per acre.

3. Fertilizers for top-dressing grass lands in spring should contain nitrate of soda and muriate or sulphate of potash; and, to benefit the rowen crop, they should contain also some slower-acting forms of nitrogen, such as sulphate of ammonia, dried blood, dry ground fish, bone meal or tankage. The fish, tankage or bone meal will furnish some phosphate, of which a moderate quantity will be useful.

Corn.

1. The application of muriate of potash has so invariably increased the yield of both stover and grain that the conclusion is irresistible that potash should be more abundant in fertilizers for this crop than is usually the case.

2. There is much evidence that the fertilizer for one acre should furnish at least 80 to 100 pounds of actual potash.

3. A corn fertilizer containing 5 per cent. of potash, applied at the rate of 1,000 pounds per acre, furnishes 50 pounds of actual potash. With such a fertilizer it will pay to use from 75 to 100 pounds of muriate of potash per acre.

4. Four cords of average farm-yard manure will supply about 96 pounds of actual potash; but not all of this will be available the first year, hence it will in most cases be found profitable to use with this manure 75 to 100 pounds of muriate of potash for corn.

Rye.

This crop is most largely increased by muriate of potash and nitrate of soda, but responds much less freely to an application of fertilizers than corn.

White Mustard.

1. In this we have a crop responding most freely to an application of phosphates, indicating that the percentage of phosphoric acid in fertilizers for turnips and cabbages (members of the same family) should be large.

2. White mustard sown yearly in standing corn in the later part of July grows until late in the fall, thus preventing soluble nitrogen compounds from being washed out of the soil. It does not injure the growth of the corn the year it is sown, and the ultimate effect is to make the soil produce larger crops in subsequent years.

Potatoes.

1. Both being used in connection with materials furnishing equal amounts of nitrogen and phosphates, sulphate of potash gives larger yields of potatoes than muriate of potash.

2. Used in the same way, sulphate of potash produces potatoes of better quality than muriate of potash.

3. Potato fertilizers should therefore contain potash in the form of sulphate rather than muriate.

4. A large share of a fertilizer for potatoes should be placed in the drill. This gives larger crops of better quality than spreading broadcast.

5. Treatment with solution of corrosive sublimate of seed potatoes which are moderately scabby will prevent scab, provided the germs of this disease are not present in the soil where the potatoes are planted.

Crimson Clover.

This clover has not proved hardy here, and experiments in its use should be tried upon a small scale.

Japanese Millets.

1. The "barn-yard" variety is worth a trial. Here it has yielded per acre: (*a*) seed, 66.7 bushels, and straw, 11,297 pounds; (*b*) green fodder, 18 tons; or (*c*) hay, 6 tons.

2. The green fodder is superior to good corn fodder in feeding for milk. It makes excellent silage.

Soja Beans.

The medium green variety is a useful crop, whether for feeding green or for silage. It will yield about two-thirds as much gross weight as corn; but is far richer in flesh formers. Silage made by mixing two parts of either corn or barn-yard millet with one of the beans makes a well-balanced feed for cows.

Flat Pea.

Seed was planted in the spring of 1894, but no fodder has as yet been produced.

Sacaline.

Seed planted in the spring of 1895 germinated well, the plants made a good start and promise a large yield of fodder next year.

Hay Caps.

A trial demonstrated their great usefulness in showery weather, and indicates that the Symmes' cap has much to recommend it.

Warming a Stable for Cows.

The increase in milk and butter due to warming a stable was small, and altogether insufficient to pay the cost.

Feeding Hens for Eggs.

1. Vegetable foods, even though furnishing equal amounts of all nutrients and in the proportions considered suitable, are shown to be much inferior to animal foods furnishing the same amounts of nutrients and in the same proportions.

2. Dried meat meal, everything being considered, appears to be superior as a feed for laying fowls to cut fresh bone.

Soil Tests.

Soil tests upon the plan agreed upon in convention in Washington in 1889 have been continued. During the past season we have carried out five such tests: two upon our own grounds, one with rye and the other with grass and clover as the crops; and one each in Concord, Hadley and Shelburne, with corn as the crop. The main points indicated are as follows: —

Grass and Clover.

1. Nitrate of soda, applied at the rate of 160 pounds per acre, is beneficial to the first crop of grass, the average increase amounting to 580 pounds per acre. This result is in line with all results in previous years, both here and elsewhere.

2. This application does not appreciably increase the rowen crop.

3. The potash greatly increases the proportion of clover, and thus considerably benefits the first cut of hay, the average increase this year amounting to 569 pounds of hay for an application of 160 pounds of muriate of potash per acre.

4. The effect of the potash application is most striking upon the rowen crop. This, where timothy, red top and clover are sown, is always chiefly clover. This year there was not rowen enough to weigh except where barn-yard manure or potash had been applied.

5. The phosphoric acid has not much affected either the first or the second cutting.

I would again recommend, for mowings containing mixed grasses and clover, as follows per acre: —

	Pounds.
Nitrate of soda,	150
Tankage of dry fish,	100
Plain superphosphate,	100
Ground South Carolina rock phosphate,	100
Muriate of potash,	150

Mix just before use and spread evenly in early spring.

Corn.

The soil tests with corn this year were all upon land which has been several years under similar manurial treatment. On Mr. Frank Wheeler's farm in Concord the work was begun in 1890, and his crops in the order of succession have been corn, corn, potatoes, grass and clover, grass and clover, and corn (1895).

On Mr. Wheeler's farm this year the average yield of the five nothing plats which have received neither manure nor fertilizer since 1889 was: stover, 3,956 pounds; grain, 40.6 bushels per acre. With muriate of potash alone, at the rate of 160 pounds per acre, the yield was: stover, 2,840 pounds; grain, 59.8 bushels. The average increase on four plats where potash was used, which is apparently due to this fertilizer, is: stover, 1,257 pounds; grain, 21.6 bushels. The average gain due to the use of nitrate of soda is 3.4 bushels of grain, that due to potash (dissolved bone-black) is 2 bushels.

On Mr. West's farm in Hadley the work was begun in 1890, and the crops have been corn, corn, oats, grass and clover, grass and clover, and this year corn. The average yield of the nothing plats per acre this year was: stover, 3,584 pounds; grain, 50.7 bushels. The increase apparently due to the application of potash alone was: stover, 2,900 pounds; grain, 27.4 bushels. The average increase on all plats where potash was used, apparently due to this element, was: stover, 3,200 pounds; grain, 22.8 bushels. Similar averages for

nitrate of soda are: stover, 407 pounds; grain, 9.1 bushels. For phosphate (dissolved bone-black) there has been absolutely no average increase; the crops where this has been applied have been in fact a very little less in every instance except one where it has been used.

On the farm of Mr. Dole in Shelburne the soil test work was begun in 1889 and has continued seven years. The crops in order of succession have been corn, corn, potatoes, oats, grass and clover, grass and clover, and corn (1895). Shelburne is the only place in the State where soil test work with corn as the crop has been carried on which has not indicated potash to be most largely required. The results have been less decisive than in most places, but have indicated phosphate (dissolved bone-black) to be most useful in former years. The past season nitrate of soda appears to have been most useful to the corn crop; but there is strong reason for believing that Mr. Dole, in placing the unhusked corn in the barn, made mistakes in marking the several bunches of material; and I regret to say that the figures are such that I believe deductions therefrom would be unreliable.

Rye.

The acre upon our home grounds which has been seven years under soil test experiments has this year been in winter rye which was sown in October, 1894. In rye we have a crop with a long period of growth which is notable for its ability to extract its food from a poor soil. It was to be expected, therefore, that the differences produced by the fertilizer treatment would be less than with crops such as corn, potatoes and oats. This has been the case; but still the results speak in no uncertain tone. The succession of crops upon this acre has been corn, corn, oats, grass and clover, grass and clover, corn and rye. For the corn, the muriate of potash has been most useful; for the oats and grass, nitrate of soda; for the clover, muriate of potash. This season the average yield of the nothing plats has been: straw, 1,700 pounds; grain, 12.1 bushels. The muriate of potash alone has increased the straw 400 pounds, and the grain 4.1 bushels. On the average, the muriate of

potash has produced the following increases, viz.: straw, 800 pounds; grain, 4.5 bushels. Neither the nitrate of soda nor the phosphate has been as beneficial. The muriate of potash is most beneficial when used with both nitrate and phosphate. The plat where all three were used produced an increase of: straw, 2,480 pounds; grain, 15.4 bushels, as compared with the nothings. Where manure at the rate of five cords per acre has been applied every year for seven years similar increases are: straw, 3,200 pounds; grain, 21.1 bushels. The grain raised on the fertilizer is better than that raised on manure, and in general the size and plumpness of berry were favorably affected by potash.

What White Mustard teaches.

Soon after the rye was harvested the land was ploughed and sown to white mustard, 40 pounds of seed being put in on July 31 without additional fertilizer. The result was a striking object lesson. Germination of the seed was quick and even, but, except on the plats where manure or phosphate (dissolved bone-black), lime and plaster have been applied, there was almost absolutely no growth. On the manure and "complete" fertilizer plats growth was characterized as good; on the plats receiving respectively nitrate of soda and dissolved bone-black, dissolved bone-black and muriate of potash, and dissolved bone-black alone, it was fair. On all others it was poor, though the plats which had received lime and plaster made a little better showing than the others. It will be noticed that where for seven years we have been applying phosphate — even with nothing else — the growth of the mustard was fair to good, while elsewhere there was very little growth; the plants simply vegetated, and then stood still. This result is especially significant upon this land, for, as shown in my description of the soil test with rye, dissolved bone-black has not very materially benefited either corn, oats, grass, clover or rye. On the same land, then, we find corn, clover and rye responding most freely to potash application; oats and grass, to nitrate of soda; and mustard, — a plant of an altogether different order (the turnip and cabbage family), — to phos-

phate. It is believed this object lesson indicates that here, as in England, where the fact has long been pointed out, fertilizers for turnips especially and probably for cabbages also should be rich in available phosphoric acid.

The fertilizers applied yearly in all the soil tests alluded to in my reports are shown in the table below. In some experiments there have been five instead of four nothing plats, as shown in this table, and the numbering of the plats has been different. In other particulars the plan in all has been identical. It has for its object not the production of large crops, but the discovery of facts concerning the special requirements of crops on the soils tested.

Applied Yearly per Acre.

No.	
1.	Nitrate of soda, 160 pounds.
2.	Dissolved bone-black, 320 pounds.
3.	Nothing.
4.	Muriate of potash, 160 pounds.
5.	Lime, 160 pounds.
6.	Nothing.
7.	Farm-yard manure, 5 cords.
8.	Nitrate of soda, 160 pounds. Dissolved bone-black, 320 pounds.
9.	Nothing.
10.	Nitrate of soda, 160 pounds. Muriate of potash, 160 pounds.
11.	Dissolved bone-black, 320 pounds. Muriate of potash, 160 pounds.
12.	Nothing.
13.	Land plaster, 160 pounds.
14.	Nitrate of soda, 160 pounds. Dissolved bone-black, 320 pounds. Muriate of potash, 160 pounds.

Potato Experiments.

Objects.

1. To determine whether the muriate or the sulphate of potash should be used as a source of potash in potato fertilizers.

2. To determine whether fertilizers for this crop should be applied broadcast and harrowed in or put into the drill.

Results.

1. Eight experiments, comparing the sulphate with the muriate of potash, have given an average of 22.1 bushels of merchantable tubers per acre more where the sulphate was the source of potash.

2. The eating quality of the tubers raised when the sulphate has been the source of potash has generally been better than when the muriate was used.

3. Analyses have generally shown that the tubers raised on the sulphate have contained less water and more starch than those raised on the muriate. When this has not been the case, it is believed to have been because the tubers had not properly ripened, owing to the premature death of the tops on account of blight.

4. There has been little difference in the appearance of the tubers raised on the two fertilizers, but the advantage is slightly with the muriate in this respect.

5. The number of bushels per acre in favor of the sulphate has ranged from 4.8 to 82.5 of merchantable tubers. In only one out of the eight experiments has the muriate excelled the sulphate; the difference on total yield was then only 28 pounds per acre.

6. The fertilizer in the drill has generally given larger crops than broadcast application. This has been the case in six out of the eight experiments, the range being from 12.5 bushels to 54 bushels of merchantable tubers per acre in favor of drill application. In the two experiments where broadcast application gave the larger crops, it is believed that the fact was due to natural inequality in the soil.

Details.

These experiments were begun in 1892, and have been continued every year. Each year we have had four plats, which we will call numbers 1, 2, 3 and 4. In 1892 and 1893 these plats were one-sixth of an acre each; in 1894 and 1895, one-fourth of an acre each. The fertilizers have each year been applied broadcast to plats 1 and 2; in the open furrow before dropping the seed to plats 3 and 4. Sulphate of potash has been the source of the potash each year on plats 1 and 3, muriate of potash on plats 2 and 4. The quantities of potash salts employed have been such as to supply equal numbers of pounds of actual potash to plats which were to be compared. Fertilizers supplying equal quantities of nitrogen and phosphoric acid to all the plats have each year been applied.

The experiments of 1892 and 1893 were upon the same land. This land had been in pasture for several years up to 1889. It was ploughed and planted in 1890 and 1891, the crops being white mustard, oats, soja beans and millets. The division into plats in the potato experiments ran across the rows of the two previous years, so that previous cultural conditions had been the same on all the four potato plats. The fertilizers applied in 1890 and 1891 comprised: nitrate of soda, 160 pounds; dissolved bone-black, 320 pounds; and muriate of potash, 160 pounds, per acre in each year. The soil of these plats is a fine medium loam, underlaid by gravel at the depth of about three feet, — an excellent soil, in so far as drainage, warmth and other physical conditions go, for the potato.

The land used in 1894 and 1895 was of the same general character, but with the gravel a little farther from the surface. The same field was used both seasons. This land had, previous to 1890, been used for several years as a pasture. From 1890 to 1893 inclusive it had been used for a variety of hoed crops, all raised on fertilizers. The conditions on all four plats had been alike, but from the nature of our results it is believed that the soil in Plat 4 is inferior in fertility to that in the other plats.

The kinds and amounts of fertilizers used per acre in each of the first three years are shown below: —

FERTILIZERS.	PLATS (1892).				PLATS (1893).				PLATS (1894).			
	1	2	3	4	1	2	3	4	1	2	3	4
Nitrate of soda (pounds),	160	160	160	160	240	240	240	240	240	240	240	240
Dry ground fish (pounds),	200	200	200	200	300	300	300	300	-	-	-	-
Dissolved bone-black (pounds),	250	250	250	250	375	375	375	375	375	375	375	375
Sulphate of potash (pounds),	174	-	174	-	261	-	261	-	211	-	211	-
Muriate of potash (pounds),	-	174	-	174	-	261	-	261	-	211	-	211
Tankage (pounds),	-	-	-	-	-	-	-	-	240	240	240	240
Dried blood (pounds),	-	-	-	-	-	-	-	-	60	60	60	60

In 1895 the same kinds and amounts of fertilizers were used on each plat as in 1894.

Manner of applying Fertilizers.

In every instance all the fertilizers to be used on a plat have been thoroughly mixed just before the seed was to be planted. On plats 1 and 2 each year all of the mixed fertilizers have been evenly spread after ploughing and at once harrowed in. On plats 3 and 4 the mixed fertilizer has been broadly scattered the full length of the open furrow in which the seed was to be dropped. In covering the seed the fertilizer was somewhat mixed with the soil and in part brought above the seed.

Seed used and Manner of Planting.

The variety of potatoes raised has every year been the same, — Beauty of Hebron. In 1892 the seed was from Aroostook County, Maine; in 1893 it was of our own raising; in 1894 all except that planted in four rows was from Maine, that in the four rows was of our own growing; and in 1895 all was from Aroostook County. In 1894 all the seed was treated with a solution of corrosive sublimate, for the prevention of scab. The treatment accomplished the object in view, and will be described later. Each year the seed has consisted of medium to large tubers, and it has been cut into pieces with two strong eyes each. It has been

planted by hand in rows three and one-half feet apart and at a distance of twelve inches in the row. Planting has always been early.

Culture and Appearance while growing.

The land has been harrowed once before the seed was up, and later the harrow or Breed's weeder has been used once or twice more. The work thereafter has been carefully and seasonably performed with one-horse cultivators and hand hoes. During the early part of each of the four seasons the crop growing where the sulphate of potash had been applied was distinctly more vigorous and of a deeper color than that growing on the muriate. This difference was maintained throughout the season, but became less noticeable towards the close of the season of growth.

A similar difference in favor of drill application was always observed, also somewhat less marked towards the close of the season.

The crops of 1892 and 1893 were not affected by leaf blight to any great extent; but those of both 1894 and 1895 were affected, and as a consequence the tubers were less perfectly matured in those years.

Yields per Acre (Bushels).

Sulphate of Potash.

1892. { Broadcast, merchantable tubers, 185.7; small tubers, 10.8.
Drill, merchantable tubers, 192.5; small tubers, 13.5.

1893. { Broadcast, merchantable tubers, 290.4; small tubers, 26.4.
Drill, merchantable tubers, 344.4; small tubers, 15.0.

1894. { Broadcast, merchantable tubers, 248.0; small tubers, 20.0.
Drill, merchantable tubers, 268.4; small tubers, 17.2.

1895. { Broadcast, merchantable tubers, 241.5; small tubers, 15.3.
Drill, merchantable tubers, 260.4; small tubers, 14.0.

Muriate of Potash.

1892. { Broadcast, merchantable tubers, 166.6; small tubers, 13.3.
Drill, merchantable tubers, 179.0; small tubers, 17.0.

1893. { Broadcast, merchantable tubers, 285.6; small tubers, 15.0.
Drill, merchantable tubers, 325.6; small tubers, 21.0.

1894. { Broadcast, merchantable tubers, 254.4; small tubers, 14.3.
Drill, merchantable tubers, 186.4; small tubers, 11.3.

1895. { Broadcast, merchantable tubers, 234.0; small tubers, 16.6.
Drill, merchantable tubers, 222.7; small tubers, 13.5.

An examination of the figures for corresponding years and plats reveals the fact that the plats receiving sulphate of potash have given the largest yield in every instance except one, viz., broadcast application in 1894. The averages for the two potash salts are as follows: sulphate of potash, per acre, merchantable tubers, 253.9 bushels; small tubers, 16.5 bushels; muriate of potash, per acre, merchantable tubers, 231.8 bushels; small tubers, 15.25 bushels. The average difference amounts to 22.1 bushels of merchantable tubers and 1.25 bushels of small tubers. The difference in cost between the two potash manures amounts to about two dollars per year, the sulphate costing the more.

It should be remarked that since some adverse influence, previously alluded to (not connected with the system of manuring), has affected the crops upon Plat 4 during 1894 and 1895 (drill application of muriate of potash), the above average difference in favor of the sulphate of potash is undoubtedly too large. If we leave this plat out of the calculation, the average difference in favor of the sulphate of potash amounts per acre to merchantable tubers, 13 bushels; small tubers, .3 bushels.

Comparison of the yields on plats receiving the same fertilizers in the different years shows that drill application has given the larger yield in all cases except where drill application of the muriate of potash is compared with broadcast application for 1894 and 1895. As previously stated, Plat 4 (muriate of potash in the drill) has evidently suffered from some inherent inequality in conditions. It therefore seems best to disregard the results of muriate of potash for the seasons 1894 and 1895 in estimating the relative merits of the two systems of application. On this basis the average difference in favor of drill application amounts per acre to 23.5 bushels of merchantable tubers.

Quality of the Crops.

In each year, soon after digging, samples of potatoes grown respectively on sulphate and muriate of potash have been sent under numbers with no other information to several families, who were requested to use them and report whether there was any difference in quality. In 1892 all

reported that the potatoes grown on the sulphate were whiter, more mealy and better flavored than the others. In 1893 they all reported that they could see no great difference between them. In 1894 and 1895 the potatoes grown upon the sulphate were with one or two exceptions reported to be superior to those grown on the muriate, in color, mealiness and flavor. Those reporting otherwise stated that they could see no great difference. In 1894 the head of one family said: "If you have potatoes like No. 1 [grown on sulphate] I would like to get my winter's supply of you; but I would not take No. 2." The season of 1893 was exceptionally hot and dry, as was also that of 1894; but the soil used in 1894 was deeper, and the crop suffered comparatively little from drought.

Moisture and starch determinations in samples of potatoes grown respectively on the sulphate and the muriate have been made every season. The results are shown below for the first three years. They are not given for the present season, because but two samples were taken: one the muriate potatoes, where the fertilizers were put on broadcast; the other the sulphate potatoes, where the fertilizers were put in the drill.

		Sulphate of Potash Potatoes.		Muriate of Potash Potatoes.	
		Water (Per Cent.).	Starch (Per Cent.).	Water (Per Cent.).	Starch (Per Cent.).
1892	Broadcast,	81.09	10.66	81.33	11.99
	Drill,	81.56	10.98	81.83	9.45
1893	Broadcast,	75.56	16.98	81.99	12.52
	Drill,	74.40	18.44	78.98	14.11
1894	Broadcast,	78.01	15.98	77.53	16.03
	Drill,	78.18	15.75	77.68	16.28

It will be noticed that in three out of the six possible comparisons the percentage of water is less and that of starch is greater in the potatoes grown on the sulphate of potash, and that the differences are considerable. In those cases where the results were favorable to the muriate, the differences as a rule are small. The averages for the two fertilizers are: sulphate of potash potatoes, water, 78.11 per cent.; starch,

14.99 per cent. Muriate of potash potatoes, water, 79.86 per cent.; starch, 13.68 per cent.

In those seasons when the muriate potatoes have compared most favorably with the sulphate potatoes, the crop has suffered from leaf blight, and has not therefore ripened as well as in other seasons. It is believed that the experiments indicate that, under average conditions of soil, season and ripening, the potatoes grown on the sulphate of potash will contain less water and more starch than those grown on the muriate.

Examination of the above table shows also that the potatoes grown under drill application of the fertilizers have usually been superior in quality to those grown where the fertilizers have been put on broadcast, containing less water and more starch. The most marked exception is on muriate of potash in 1892; but it appears not unlikely that there was an error in the analysis, since the proportion of water in the drill potatoes is nearly the same as in those grown where the fertilizers were broadcast. It will be noticed that elsewhere the variations in water and starch are about equal in amount, but in opposite directions. When there is more water there is less starch, and *vice versa*. Leaving out the muriate plats for 1892, the averages are: for drill application of fertilizers, water, 78.2 per cent.; starch, 14.9 per cent. Broadcast application of fertilizers, water, 78.8 per cent.; starch, 14.4 per cent.

It is undoubtedly the better ripened condition of the tubers raised under drill application which accounts for their superiority.

Maine compared with Home-grown Seed.

In 1894 Houlton seed in quantity supposed to be sufficient for the entire area under experiment was obtained. It proved insufficient, and the last four rows in each of the four plats were planted with seed grown upon the farm the previous year. These potatoes were raised from Houlton seed. The season of 1894 was, therefore, the first removed from the Maine stock. The results were decidedly in favor of the Houlton seed. The plants started quicker and more vig-

orously, and maintained their superiority throughout the entire season. At harvest the superiority of the crop from the Houlton seed was marked. Each kind was separately weighed on each plat. On Plat 1, Maine seed yielded at the rate of 399.5 pounds more than home seed; on Plat 2, 454 pounds more; on Plat 3, 605.5 pounds more; on Plat 4, 548 pounds more. Per acre the difference in favor of Maine seed amounted to 36.5 bushels, — far more than enough to repay the usual difference in the cost of the two kinds of seed.

Treatment of Seed with Corrosive Sublimate.

In 1894, as the seed to be used showed a little scab, it was all treated with corrosive sublimate solution. Two and one-fourth ounces of corrosive sublimate were dissolved in fifteen gallons of water. The seed was at first washed with a hose, being spread in a shallow inclined trough. After draining, the seed was put into the solution and allowed to remain one and one-half hours. It was then taken out, spread and allowed to dry in the sun, being cut and planted about as soon as it was dry. Corrosive sublimate can be purchased of druggists. It is a dangerous poison if taken into the stomach, but it is not at all dangerous to handle the seed thus prepared. The same solution can be used several times if all the seed cannot be put in at once. Care should be taken to use wooden vessels for the solution, as it will corrode metals. After use the solution should be thrown away in such a manner as to make it certain that animals cannot get hold of it, and where it cannot contaminate wells, springs, streams or ponds.

The treatment is effective in preventing scab where the germs of the disease are not present in the soil, — *i. e.*, on land where scabby potatoes have not been grown for several years. The method was perfected by Professor Bolley of North Dakota, and is fully described in Bulletin No. 9 of that station.

Variety Tests of Potatoes.

Sixty-five varieties of potatoes have been grown during the past season. With few exceptions we procured three pounds of seed of each variety. This seed came from many different sources and was of very varied quality and excellence, both as regards original characteristics and conditions as affected by keeping and transportation. It is not believed that with seed of the different varieties of such unlike character it is possible to make comparisons of permanent value between the varieties. We now have a supply of seed of each sort raised by ourselves under precisely the same conditions. It will be kept and managed alike for all varieties. With such seed to start with, and planted under appropriate conditions, we shall obtain results of value for purposes of comparison.

Meanwhile the following details will be of interest, as illustrating to what an extent the crop is influenced by the seed. The seed of all varieties was cut into pieces of two eyes each, with a very few exceptions where this would have made the pieces extremely small. One row of each sort was planted. Its length was forty feet, the pieces being placed twelve inches apart in the row. The distance between the rows was uniform, three and one-half feet. With the exception of two or three sorts which arrived late, all kinds were planted on the same day. The tops of all were prematurely killed by the blight due to *Macrosporium*, and at about the same time. Full notes have been put on record regarding peculiarities in growth, and the character of the crop harvested. The yield of each has been recorded, — it varies from $24\frac{1}{2}$ to $71\frac{1}{4}$ pounds merchantable potatoes. Six varieties gave a total yield of more than 60 pounds, twenty-three varieties between 50 and 60 pounds, seventeen varieties between 40 and 50 pounds and sixteen varieties between 30 and 40 pounds. The balance gave under 30 pounds total yield. A yield of 60 pounds is equivalent to about 315 bushels per acre. The best variety, then, yielded at the rate of about 368 bushels of merchantable tubers per acre, the poorest at the rate of about 125 bushels.

The soil was a medium, well-drained loam. It received a

dressing of manure in December, 1894, at the rate of 7 cords per acre. We used fertilizers, mixed and applied in the drill at the following rates per acre: —

	Pounds.
Nitrate of soda,	120
Dissolved bone-black,	187½
Sulphate of potash (high grade),	105½
Tankage,	120
Dried blood,	30

Manure alone *v.* Manure and Potash for Corn.

The experiment to test the value of manure and potash as compared with a larger quantity of manures alone for the corn crop has been continued, the past being the fifth successive year of similar treatment. Where manure alone was used we applied at the rate of 6 cords per acre, spread after ploughing and harrowed in. The manure and potash similarly applied have been put on at the rate of 4 cords of the former and 160 pounds of muriate of potash for the latter. The plats, four in number, contain one-quarter of an acre each. The results are shown below: —

Plat No. 1, manure, stover, 1,367 pounds; corn on the ear, 1,227 pounds
Plat No. 2, manure and potash, stover, 1,223 pounds; corn on the ear, 1,065 pounds.
Plat No. 3, manure, stover, 1,025 pounds; corn on the ear, 1,266 pounds.
Plat No. 4, manure and potash, stover, 987 pounds; corn on the ear, 1,160 pounds.

The manure used was made by cows, that applied to Plat 4 being not as good as that applied to the other plats.

The application made furnished plant food at the following rates per acre: —

FERTILIZERS.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plat 1, manure alone,	126.4	99.9	232.2
Plat 2, manure and potash,	96.2	67.5	260.8
Plat 3, manure alone,	109.1	100.3	217.8
Plat 4, manure and potash,	83.8	90.4	224.6

It will be noticed that where manure alone was applied considerably more nitrogen and phosphoric acid have been supplied than on the other plats, while the quantity of pot-

ash also is large. It will not be wondered at that after five years of such treatment these manure plats are yielding larger crops than those receiving smaller amounts of manure and potash. The average difference in favor of the manure alone this year is at the rate of 6.8 bushels of grain and 364 pounds of stover per acre, — not enough to cover the larger cost of the manure, as compared with the cost of the lesser amount of manure and the potash. The crop per acre is worth this year $4.17 more when manure alone was applied; but the 6 cords of manure must be reckoned as costing $6.80 more than the 4 cords of manure and the 160 pounds of muriate of potash.

Special Corn Fertilizer *v.* Fertilizer containing More Potash.

Many soil tests in different parts of the State having indicated that fertilizers for corn should contain a larger proportion of potash, an experiment in continuous corn culture was begun in 1891. There are four plats of one-fourth of an acre each, on two of which the "special" furnishes the amounts of nitrogen, phosphoric acid and potash that would be supplied by the application of 1,200 pounds of a fertilizer having the average composition of all leading kinds offered in our markets in 1891.

The materials used are shown below: —

FERTILIZERS.	Plats 1 and 3 (Pounds).	Plats 2 and 4 (Pounds).
Nitrate of soda,	55½	33
Dissolved bone-black,	213	112½
Muriate of potash,	27	75

The yields the past year are shown below: —

Plat 1, "special" fertilizer, stover, 1,092 pounds; grain on ear, 1,112 pounds.

Plat 2, fertilizer richer in potash, stover, 1,199 pounds; grain on ear, 1,055 pounds.

Plat 3, "special" fertilizer, stover, 958 pounds; grain on ear, 1,220 pounds.

Plat 4, fertilizer richer in potash, stover, 1,100 pounds; grain on ear, 1,190 pounds.

Computed to the acre and the grain in bushels, the averages are: "special," stover, 4,100 pounds; grain, 58.3 bushels; fertilizer richer in potash, stover, 4,598 pounds; grain, 56.1 bushels. Here, as in the comparison between "manure" and "manure and potash," there is rather more stover and a little less grain where the greater amount of potash is used. The "special" produces this year, per acre, 2.2 bushels more grain and 498 pounds less stover than the combination with more potash. The increase in stover due to the greater amount of potash is worth about $1.10 more than the increase in grain due to the "special;" hence, as the fertilizer richer in potash costs about $2.52 less per acre than the special, there is a net advantage amounting to $3.62 per acre in favor of the former.

It is believed that by *the introduction of plants of the clover family* (*nitrogen traps*), which from experiments here and in many other places we are justified in concluding would grow more luxuriantly where the larger amount of potash has been used than where "special" has been applied, the advantage of the larger potash application could be much increased. An effort to demonstrate this fact has been made in each of the seasons of 1893 and 1894 by sowing *crimson clover* on one-half of this acre; but, owing to the *winter-killing* of this *clover* both years, the effect, though favorable, is small. Per acre the yields have been: where crimson clover was sown, stover, 4,512 pounds; grain, 58.6 bushels; without clover, stover, 4,186 pounds; grain, 55.9 bushels. The clover has been sown in the standing corn in July, and turned under just before planting the corn the following spring.

Hill *v.* Drill Culture for Corn.

On plats 1 and 2 in both the corn experiments just described the corn was planted in drills; on plats 3 and 4, in hills. We have left equal numbers of plants to a plot in both systems. All rows were three and one-half feet apart; hills with three plants each, three feet apart; plants in the drill one foot apart. In both experiments the hill system has produced rather more grain and less stover than the drill. The average figures per acre are as follows: manure

v. manure and potash, hills, stover, 4,024 pounds; grain, 60.7 bushels; drills, stover, 5,180 pounds; grain, 57.3 bushels; "special" *v.* fertilizer richer in potash, hills, stover, 4,116 pounds; grain, 60.3 bushels; drills, stover, 4,582 pounds; grain, 54.2 bushels. Averaging both experiments, the drill system produced the more valuable *total* crop.

White mustard as a crop for nitrogen conservation has been sown on one-half of the acre of corn where *manure alone* is compared with *manure and potash* every year since 1892. The mustard seed is sown in the standing corn in July, at the rate of 24 pounds per acre. Its growth from year to year has varied greatly, as in very dry seasons it does not start well. The past two seasons the growth has been light. It is ploughed in late in the fall. The beneficial effect is apparent, and is doubtless largely due to the fact that the mustard, which grows till very late in the season, prevents in a measure the loss of soluble nitrogen compounds by leaching. It acts as a *nitrogen conserver*. The averages this year per acre are as follows: with white mustard as a green manure, stover, 4,828 pounds; grain, 61.7 bushels; without the mustard, stover, 4,376 pounds; grain, 56.3 bushels. *Gain by green manuring*, stover, 452 pounds; grain, 5.4 bushels.

Japanese Millets.

Panicum crus-galli.

The Japanese millet of this species, which I propose to call "barn-yard" millet, because it is of the same species as the common barn-yard grass, has been very thoroughly tried the past year, for seed, for green fodder and for hay.

For Seed. — For seed purposes we raised about three-quarters of an acre. The land, in very moderate fertility, was manured at the rate of 6 cords per acre of good manure in December, 1894, and after ploughing this spring the following materials per acre were spread on (mixed) and harrowed in: nitrate of soda, 100 pounds; dissolved bone-black, 200 pounds; and muriate of potash, 100 pounds. The seed was put in with a small seed sower, in drills fifteen inches apart. It was wheel-hoed, and kept free from weeds. The

crop was very even, averaging seven feet in height. The yield was at the rate per acre: straw, 11,297 pounds; and seed, 66.7 bushels.

For Green Fodder and the Silo. — Several pieces of an acre or more each were sown for feeding green or for the silo. The earliest, sown broadcast about the middle of May on rich land, one peck of seed to the acre, averaged about six feet in height and produced over 15 tons per acre. This was cut from day to day, beginning before the millet had blossomed. Another field of about an acre, sown the last of June, yielded at the rate of rather over 18 tons per acre. Another field, sown July 26, after a crop of hay was removed, yielded about 12 tons per acre. The crop of the two last fields was put into the silo. That cut from day to day and fed green to cows was much relished. Its superiority to well-eared flint corn fodder was very apparent. Cows with both before them always take the millet first; they consume it without waste, while they are apt to leave a part of the stalks of the corn as it approaches maturity. In alternating this feed with corn fodder, the cows invariably increased in milk when put upon the millet and fell off when changed to corn.

It has been ensiled with soja beans, — about two parts by weight of the millet and one of the beans. This combination makes very superior silage.

For Hay. — A more extensive trial of this millet for hay has been carried out this year than ever before. It is coarse and difficult to dry. I have always felt that these qualities would render it undesirable as a crop for hay. We have, however, cured it successfully this year, mostly in small cocks, as clover is often cured; and the result is encouraging. The hay is coarse, but is freely eaten by horses, being preferred to a good sample of timothy, red top and clover mixture. The yield of the millet is very large, having on good land amounted to 6 tons per acre of well-cured hay. It will produce a fair second cutting if sown early in May and cut when in blossom.

The soil best for this millet is one that is rather retentive and rich. It stands up remarkably well, notwithstanding its great height. From a peck to a half bushel of seed, accord-

ing to the richness of the land and the season of sowing, is enough. Less seed the richer the land and the earlier the season should be the rule. This millet will not endure drought well, except it be sown early in retentive soil. From early corn-planting time to about July 1 will usually be the limits of season for profitable sowing.

Panicum miliaceum.

This species, some other varieties of which are known as "panicle," "broom-corn" and "French" millets, I shall speak of hereafter as "Japanese panicle" millet. It has been grown upon a small scale for seed the past year. The area was a little less than a quarter of an acre. It received at the rate per acre: nitrate of soda, 175 pounds; dissolved bone-black, 320 pounds; and muriate of potash, 175 pounds, — all mixed, sown broadcast and harrowed in. The seed was thinly sown in drills, fifteen inches apart, and cultivated and kept free from weeds. The yield was at the rate of: straw, 5,856 pounds; seed, 34.1 bushels per acre. This variety is liked for fodder by some who have tried it; but I regard it as inferior to the barn-yard millet for that purpose. The seed is valuable for poultry and birds.

Panicum italicum.

The Japanese variety of this species has been grown for seed; soil, manure and fertilizers, as well as manner of planting and care, the same as for "barn-yard" millet. It yields at the rate per acre: straw, 3,836 pounds; seed, 66.4 bushels. This variety is of value for fodder, but I prefer the "barn-yard" variety.

Variety Tests with Millets.

Twenty-seven varieties of millet have been grown upon a small scale, for purposes of comparison. With three exceptions four rows, each thirty feet long, were planted. Of these, owing to our inability to procure enough seed, we had but one or two rows. Careful observations have been put on record, but only for preliminary purposes, as the scale of work was small. The gross yield varied from 11 to 49

pounds. Six varieties yielded above 40 pounds; six, from 30 to 40; seven, from 20 to 30; and eight, between 10 and 20 pounds. Four varieties, "White French," "broom corn," "hog" and "California," appear to be identical. The "pearl" millets are too late to perfect seed here. The Japanese (*italicum*) excelled either the "golden" or the "golden wonder."

Variety Tests with Turnips.

Preliminary tests have been made with thirty-two varieties of turnips. There were among the number numerous kinds which appear to differ from others only in name, and there was a wide difference in yield and quality. Further work must be done before reporting details.

Soja Beans.

Early White. — Grown for seed; area, .49 acre; yield, 18¼ bushels per acre. This variety is too small for fodder. It ripens as surely here as our common field corn. The beans ground are slightly superior in feeding value, for milk, cream or butter, to cotton-seed meal, but the yield is rather small. The cultivation costs about the same as that of corn for equal areas. The vines shed their leaves before the pods are ripe, and hence they have very little feed value. The manurial value of the straw is about $2.40 per ton.

Medium Black. — This variety, though later than the above, has ripened here every year for the last seven. It has been grown this year both for seed and for the silo. For seed: area, .6 acre; yield, 14 bushels per acre. This variety rusted somewhat this year. We put the product of .45 acre into the silo, mixed with about two parts by weight of barn-yard millet. The yield was at the rate of 12,922 pounds per acre. This crop stood about three and one-half feet high. It is better for fodder than the early white, but appears to be much inferior to the medium green variety for that use.

Medium Green. — This variety is a little later than the last. It has ripened every year until this without injury.

This year it was somewhat injured by frost; but we have nevertheless secured a very good crop of seed. Area for this purpose, .6 acre; yield, 14 bushels per acre. We put the product of .45 acre into the silo with millet, as just described. The crop averaged nearly four feet in height, and was heavily podded. The yield was 20,644 pounds per acre. I look upon this as a very valuable fodder variety, either for feeding green or for the silo. It is a rich nitrogenous feed, and (of great importance) it can take much of its nitrogen from the air. Its roots here are very thickly covered with tubercles containing the bacilli which give it this power. For comparison, I give figures showing the analysis of this bean fodder and those for corn fodder: —

	Per Cent.
Medium green soja bean, pods formed, but not hardened, dry matter,	30.16
Longfellow corn fodder, ears glazed, dry matter, ...	27.81

Composition of Dry Matter (Per Cent.).

	Protein.	Fat.	Cellulose.	Carbo-hydrates.
Medium green soja bean, . .	19.35	3.87	23.51	40.30
Longfellow corn fodder, . .	9.79	3.26	18.27	63.11

The protein is classed as a flesh former, the other substances above named are fat and heat producers. The flesh formers and the fat of fodder are the most valuable of these constituents, pound for pound; the cellulose or fibre is the least valuable. On the farm here our average yield of corn fodder is about 16 tons per acre, while the green soja bean gave this year a little over 10 tons. The amounts of the different food constituents produced are as shown below: —

Food Constituents per Acre (Pounds).

	Flesh Formers.	Crude Fat.	Fibre.	Fat and Heat Producers.
Green soja bean, ...	1,167.2	233.4	1,418.1	2,430.9
Longfellow corn, ...	871.3	290.1	1,626.0	5,616.8

It will be noticed that the bean produces about 300 pounds more flesh formers than the corn, but that the latter gives us over 3,000 pounds more fat and heat producers. These consist chiefly of starch and sugar, both of which are easily digested and valuable foods. The differences in crude fat and in fibre are much smaller, but the balance is slightly with the corn. There can be no doubt, then, that the latter produces the more valuable crop of the two, and the cost of production for equal areas does not differ very materially. In three respects, however, the bean is superior to the corn; viz., (1) it can draw much of its nitrogen from the air; (2) the bean stubble and roots probably have greater manurial value than those of corn; and (3) the bean, being so rich in flesh formers, may take the place of such concentrated foods as cotton-seed meal, linseed meal, gluten meal, etc.

Silage made from either barn-yard millet or corn and medium green soja bean, in the proportion by weight of about two parts of either of the two former to one of the latter, makes a perfectly balanced ration for milch cows, without grain or other feed of any kind. It is not believed that it would be advisable to feed altogether upon this material, for cows like variety, and it is possible that continuous use of a fermented feed like silage would have a prejudicial influence upon health. A combination of such silage and clover hay or clover rowen — about two parts of the silage to one of the hay by weight — would, I believe, give good returns in milk. This particular system of feeding has not yet been tried here.

Miscellaneous Crops.

We have had under trial a number of miscellaneous crops, including *Cystisus proliferous albus*, a new fodder plant sent on for trial by J. M. Thorburn & Co.; yellow millo maize, from the United States Department of Agriculture; two varieties of dent corn, from South Dakota; black barley; spring wheat, from South Dakota; horse bean; sacaline; flat pea and the mummy field pea. None require extended notice at present.

Cystisus (no common name is given) vegetated slowly and made a slow growth. It appears to be hardy, remain-

ing green until November 5, when it was three feet high, with small and woody stalks. It has produced no fodder as yet.

Yellow millo maize is a sorghum, and, like all other varieties of this species, grows slowly at first. Planted with corn, it was eight to twelve inches high when corn was thirty. It has the reputation of enduring drought well; but our seasons are not long enough for it, and I consider it of no value as a fodder crop here.

One of the dent corns from South Dakota appears to be a very valuable sort. It is a white variety. The seed of but two ears was planted, and upon soil of very ordinary fertility. The stalk is short and small, the ears large and deep kernelled, the variety early. The yield was at the rate of 89.6 bushels of grain to the acre.

The *spring wheat* and *black barley* did poorly, rusting and giving very small returns.

Horse Bean. — We received one peck of seed from a dealer in Montreal. It was planted in drills eighteen inches apart, in deep, clayey, rich soil, on April 29. The growth was vigorous and healthy, but few pods formed. The height was from four and one-half to five feet. It was cut from day to day, beginning July 17, and fed to cows, being highly relished. The total weight was 2,035 pounds, or at the rate of a little over 12 tons per acre. This yield of so highly nitrogenous a fodder makes it of possible value.

Sacaline. — Seed was procured of Gregory & Son of Marblehead, and sown in a bed in the open air April 23. The germination was slow, but good. Early in July the little plants were taken up and reset about three inches apart each way. About the middle of August plants were set in the field three feet apart each way. Two widely different soils were selected, — one a heavy, rich, moist loam, the other a dry, sandy loam. The plants in both soils lived well, and those in the moist, rich land made considerable growth, though not enough to be worth harvesting. A few stems cut and offered to cattle were freely eaten. The plant is perennial, and should next season produce considerable fodder which may prove valuable for green feed or for the silo.

Flat Pea. — The past is our second season with this much-lauded fodder plant. The germination last year was slow and imperfect. This year the plants have been gathered upon a lesser area, some being taken up to fill vacancies on the part left. The soil is light and dry. We have in the two seasons been at a very considerable expense, and as yet have no fodder; but, as the plant is perennial, this may come later. It is hardy with us upon light soil.

Mummy field peas are larger than the common Canada field pea, and about one-fourth to one-half more seed should be sown. We used at the rate per acre of one bushel of each with two bushels of oats for fodder. The mummy variety was not thick enough. In one respect it appears superior to the Canada; viz., it lodges less. This difference may, however, have been in part due to the fact that the mummy variety was the thinner in the field. The yields of the two fodder mixtures, as determined by calculation based upon small equal areas, were: oats and Canada pea, 21,760 pounds, and oats and mummy pea, 19,040 pounds, per acre.

Trial of Hay Caps.

Three kinds of hay caps have been subjected to careful comparative tests. The kinds tried were the Symmes' paper-board cap, oiled cotton, and cotton impregnated with tannin. The first was not fastened in place, its weight and construction rendering this less necessary than for the other forms. It, however, sometimes blew off in high winds. The others were fastened on by means of pins attached to cords at the corners.

Three trials were made, two with clover rowen which had been dried one day, and one with barn-yard millet which had been dried three days. After the caps were put on the first trial continued seven days; the second, two days; the third, with millet, seven days. During each trial there were one or more showers. In every trial the use of the cap was very beneficial. The paper cap excluded the rain most perfectly, and the hay in each trial came out in best condition. There was not much difference in the condition of the hay under the other two kinds of caps. As the

Symmes' paper cap can be put on fully twice as rapidly as the forms requiring fastening, it appears to be most useful. Its weight is an objection, and of course we are not yet able to report upon durability.

Experiment in Warming a Stable for Cows.

This experiment was continued during the winter of 1894–95, beginning December 18 and continuing until March 8. It will be remembered that our stable has two similar wings, one piped for hot-water heating. We aimed to maintain a temperature of about 55° F. in the warm stable. The other, of course, varied with the weather; but, as both stables are thoroughly constructed, even the "cold" side was seldom excessively cold. Six cows were used in the experiment, three on each side. We divided the time into four periods of equal length. At the close of the first period the cows changed stables. Here they were kept for two periods, and were then changed again. In this way we equalized conditions for the two stables. Between periods, when a change in the position of the cows was made, we allowed an interval of one week, that the animals might become accustomed to and under the influence of their new quarters before the records were begun.

The apparent influence of the warm stable upon milk and butter fat production is small. On the average, there is rather more milk and butter fat in the warm stable. The most certain effect brought out by our experiments is the lowering of the percentage of fat in the milk in the warm stable. The increased product will not nearly pay the cost of heating the stable.

With moderate artificial heat better ventilation can be secured, without making the stable too cold for the comfort of its occupants, than is possible without artificial heat. This should have an ultimate influence upon health; but the tuberculin test, as well as physical examination, indicated all our animals to be in perfect health at the close of the experiments, hence we as yet have nothing conclusive upon this point.

Poultry Experiments.

These have been upon a small scale, on account of location and limited equipment. We have had four coops of laying fowls, raised in 1894. There have been from fifteen to nineteen hens in a house. The houses are exactly alike in construction, each with nesting and laying room, ten by twelve feet; and scratching shed, eight by ten feet in size. The hens were of two breeds, — light Brahma and barred Plymouth Rock.

We have confined our attention to two points: —

1. The relative value for egg production of vegetable as compared with animal substances for furnishing the greater part of the albuminoids and fats of the food.

2. The relative value for egg production of animal food in the form of dried "animal" or "flesh" meals, as compared with cut fresh bone.

1. Vegetable v. Animal Albuminoids.

Two experiments have been carried out: one extending from Dec. 9, 1894, to Feb. 12, 1895; the other from June 1 to Oct. 31, 1895. The first experiment began when the fowls were pullets, hatched in May; the second includes a considerable proportion of the time occupied in the annual moult. These facts account in part for the small egg production. During the summer experiment the fowls had the run of small grass yards.

The material used in the first experiment to furnish the vegetable substitute for animal food was soja-bean meal. This is an exceptionally rich vegetable substance, in composition excelling meat meal, as will be seen from the figures below: —

Composition of the Dry Matter, Soja-bean Meal and Meat Meal (Per Cent.).

FOOD.	Flesh Formers.	Fat.	Heat and Fat Formers.
Soja-bean meal,	34.37	16.38	45.22
Meat meal,	35.98	8.31	–

Moisture: soja-bean meal, 11.61 per cent.; meat meal, 13.68 per cent.

In the second experiment linseed and cotton-seed meal were used as the vegetable substitutes for animal foods.

In both experiments the fowls received a variety of foods, but the nutritive ratio was always kept substantially the same for the two coops under comparison. In the first experiment the ratio was one flesh former to four and one-half fat and heat formers; in the second it was one to four and seven-tenths. The foods used in the first experiment, in addition to the soja-bean meal and meat meal, were: cut alfalfa, wheat, oats and middlings in one coop; in the other, boiled potatoes, ground clover, wheat, wheat middlings and cut bone.

In the second experiment the supplementary feeds were: wheat, oats, bran and middlings for the vegetable coop; and wheat, oats, wheat meal, bran and linseed meal for the animal food coop.

Both coops had pure water, artificial grit and ground oyster shells always before them; and all other conditions were made as nearly as possible alike.

The result in both experiments has been favorable to the animal food, as shown by the following summary: —

Vegetable v. Animal Foods for Hens.

FOOD.	Duration of Experiment (Days).	Daily Cost per Fowl.	Number of Eggs.	Water-free Food per Egg (Pounds).	Cost per Egg.
Vegetable food, first coop,	64	$0 0021	11	23.830	$0 3410
Vegetable food, second coop,	153	0027	400	.917	0150
Animal food, first coop,	64	0024	79	3.554	0550
Animal food, second coop,	153	0033	622	.773	0115

In the above estimate of cost no charge is made for labor and no allowance for the droppings. The production of eggs is, of course, very small, even in the best period; but it should be remembered that, at the very time when hens always lay most freely, our fowls were taken out of this experiment for breeding purposes, viz., from February 12 to June 1.

The results are, however, decisive against the vegetable food and in favor of the animal in so far as effect upon egg

production is concerned. The fowls receiving animal food were, moreover, in much better condition at the close of these experiments than the others.

2. Dried Animal or Meat Meal compared with Cut Fresh Bone.

There were two experiments. The general conditions were the same as in the comparison of vegetable and animal foods. The nutritive ratio was nearly the same in coops compared. A variety of foods was supplied; artificial grit and oyster shells were given *ad lib.* The results are shown below: —

FOOD.	Duration of Experiment (Days).	Daily Cost per Fowl.	Number of Eggs.	Water-free Food per Egg (Pounds).	Cost per Egg.
Dried meat meal, first coop, .	64	$0 00266	185	1.185	$0 0170
Dried meat meal, second coop,	153	00280	417	1.051	0152
Cut fresh bone, first coop, .	64	00248	163	1.154	0170
Cut fresh bone, second coop, .	153	00300	444	.978	0143

These results are rather indecisive, as in one experiment the meat meal and in the other the cut fresh bone gave the better results, as measured by egg production. The condition of the fowls receiving the meat meal has, however, been uniformly better than in the other coops. There has been no diarrhœa. In the second experiment, two hens in the cut-bone coop died; and at the close of this experiment the fowls which had been receiving meat meal were nearer through moulting than the others.

Of course it is possible that the bone was not used in the best practicable manner; but it appears to be exceedingly difficult to secure an even distribution of this food. Some hens almost invariably secure more than their share, and this is equally true, whether the cut bone be scattered or mixed in a mash. The result is frequent diarrhœas. The meat meal, on the other hand, can be evenly mixed in a mash, so that all fowls share alike, as it cannot be picked out. Our results indicate that it is a safer feed than the bone; it is also a much cheaper feed; and, if it will give practically as many eggs, it is to be preferred. This experiment will be repeated.

REPORT OF ENTOMOLOGIST.

CHARLES H. FERNALD.

During the past year a great deal of time has been devoted to arranging and supervising experiments on the gypsy moth, and also to preparing, in conjunction with the field director, Mr. Forbush, a full report on this insect. The Commonwealth of Massachusetts has spent and is still spending large sums of money for its destruction, and in protecting the farmers of the State from the ravages of this notorious pest. It seemed wise and proper to devote much time and attention to the study of the gypsy moth and its habits, for the purpose of discovering the best and most economical methods for its destruction.

A large amount of time has been spent in preparing a complete account of our *Crambidæ*, which appears with six colored plates and structural details elsewhere in this report. This paper is designed to give all known scientific and practical knowledge that we possess about these insects, and it is hoped that the illustrations, in connection with the descriptions, will enable our farmers to determine any of these insects, and when they are found in large numbers in their grass lands, as often occurs, they may be better able to combat them.

Bulletin No. 28 was prepared by this division, and contains descriptions and illustrations of two species of canker worms, the army worm, the red-humped apple-tree caterpillar, the antiopa butterfly, the currant stem-girdler, the imported elm-bark louse and the greenhouse orthezia, together with methods of holding them in check.

On the 29th of March, my attention was called to some scale insects on several young plum trees on the grounds of

the horticultural department of the Massachusetts Agricultural College, which proved to be the dreaded San José scale. These trees, according to the record books, came from the J. T. Lovett Company, Little Silver, N. J., in the spring of 1894.

Wishing to determine whether any of these insects had survived the winter, I had two of the trees taken up and set out in the cold part of the insectary greenhouse, and the remaining infested trees were burned. Scales appeared on the growth of the previous year, so that the insects succeeded well at least during the summer of 1894. On June 10, live scales were observed on the trees transplanted to the insectary greenhouse, and on the 14th the young were swarming all over them, and even extended to some small apple trees growing near in the same part of the greenhouse. As this seemed to settle the question of their ability to survive our winters here in Amherst, or at least the winter of 1894–95, which was an average one, I had all these trees very carefully burned, to prevent any further spreading of the pest. As soon as it was discovered that the San José scale had been received here on nursery stock from outside of the State, I feared that other nurseries might have become infested in a similar manner, and therefore I sent Mr. Lounsbury, who was my assistant at that time, to different nurseries to look for them. He reported that on April 19 he found the San José scale on two plum trees, two pear trees and a rose bush in Roslindale, Mass. The plum trees were badly infested with living scales, while the pear trees and rose bush were but slightly so. The scales occurred on all parts of the trees, but were the least numerous on the new growth. The pear trees had been on the grounds for three years and the plum trees two years. Mr. Lounsbury was informed that these trees were obtained from a local agent at West Roxbury, who claimed to have purchased them from the Shady Hill nursery, Bedford, Mass. On April 23 Mr. Lounsbury visited the Shady Hill nursery, and found the San José scale alive in large numbers on several different varieties of apple trees. Mr. Kohler, in charge of the nursery, told him that these trees were brought from the Cambridge nurseries, where they had been growing three or four years.

The Cambridge nursery was then visited, and pear, peach and apple trees were found infested with the scale, and many of the worst-infested trees were dead. As no stock had been added to this nursery for three years, these trees must have been infested at least that length of time. I have not been able to learn from what source the stock in this Cambridge nursery was obtained.

On July 9 I received a twig of an apple tree from Mr. W. W. Rawson, with the request to inform him what the matter was with it. An examination showed that it was infested with the San José scale. Further correspondence revealed the fact that the twig came from an apple tree in the orchard of Mr. E. E. Cole, in the town of Scituate. Mr. Cole wrote me that the orchard contained ninety trees that were set out three years ago. It is situated in a protected spot, with trees on three sides, and is within two miles of the ocean in a direct line. He also wrote me that the trees were received from Mr. Rawson, who informed me that he obtained most of his nursery stock of that description from the Shady Hill Nursery Company.

It is therefore probable that the Shady Hill nurseries received infested stock from some outside nursery, possibly in New Jersey, and have unintentionally become a centre of infection for orchards in the eastern part of this State. To what extent this pest has become distributed through the State it is impossible to say, but that it is able to live and destroy fruit trees in some if not in all parts of the State seems evident. A complete account of this insect was prepared and published with illustrations in the Massachusetts Crop Report for August.

The correspondence is steadily increasing, and many letters about injurious insects are received from nearly every part of the State. Most of these letters call for information about such insects as are causing more or less damage, and it is very rarely that we are called upon to give information about insects that have merely excited the curiosity of the sender.

The elm-leaf beetle appears to be rapidly spreading in the State, and we have been called upon frequently during the year for information about this beetle. A bulletin will soon

be prepared on this and several other insects, which are so numerous as to cause much damage in various parts of the State, and about which we receive frequent inquiries.

Our studies on the cranberry insect are progressing as fast as other matters will permit, and it is our intention to prepare as complete a report on these insects as possible, at some future time.

REPORT OF HORTICULTURIST.

SAMUEL T. MAYNARD.

Owing to the recent separation of the horticultural and botanical divisions, the report from this division will partake more of an outline of the work to be undertaken than of results obtained.

The work has been carried on much in the same lines as in previous years. The season, up to the time of the severe hail storm, September 11, had been one that promised more than the average for the growth and perfection of nearly all of the crops under cultivation, and insects and fungous pests were not more than usually abundant. On September 11 one of the heaviest hail storms ever known in this section occurred, which resulted in almost the total destruction of the crops not matured at that time.

Protection of Crops from Insects and Fungous Diseases.

In growing the various fruit, vegetable and other crops, it is found necessary to protect them from insects and fungous pests, and much work has been done in using and testing insecticides and fungicides.

The lines of work pursued have been for the most part confined to testing large and small fruits, especially new varieties of promise; the various insecticides and fungicides recommended for their power to protect from common insect and fungous pests; all new varieties of vegetables and flowers sent in for trial by the originator or introducer, and some of the most promising obtained in the open market. Many new and promising ornamental trees and shrubs have been planted for comparison, and many new varieties of

flowering and bedding plants have been added to the collection under glass. Comparisons have also been made respecting the effects of various kinds and different combinations of fertilizers upon growing crops.

Equipment.

This division requires for comparison a large number of standard varieties. These are already provided in the college orchard, vineyards, garden and greenhouses. In this work of comparison the most careful, painstaking observation is demanded. Suitable land is also required for the best growth of each crop, and a great variety of implements and tools for cultivating the same. Each different process requires its own tool, and facilities for storage must be provided, in order to market to the best advantage.

Varieties of Fruits.

The varieties of fruits now under observation on the college grounds may be enumerated as follows: —

Apples, 150 varieties; pears, 67; peaches, 49; plums, 103 (including types of all the groups according to the latest grouping); apricots, 13; nectarines, 2; quinces, 8, and many seedlings; cherries, 33; grapes, 143, and more than 500 seedlings not fruited; currants, 20; gooseberries, 17; red raspberries, 25, and many seedlings of the Shaffer type; black-cap raspberries, 31; blackberries, 21; strawberries, 157 named varieties, and about 600 seedlings from carefully crossed and selected varieties. Besides the above, there are growing many of the newer fruits, like the Japanese wineberry, May berry, salmon berry, Logan berry, strawberry-raspberry, Rocky Mountain cherry, sand cherry, June berry, Japanese walnut, Spanish, Japanese and hybrid chestnuts.

Spraying Outfit.

Machine Pumps. — The expense of applying insecticides and fungicides by hand pumps has been so great in the past that most of the work during the season just elapsed has been done with the Victor machine pump, resulting in a great saving of time, the power being applied by gearing attached to the

wheels. This pump was worked very satisfactorily with all growths except large trees, where the time required to spray a single tree is so great that the power acquired by the motion of the wheels becomes exhausted before the tree is thoroughly sprayed in every part. This has necessitated driving around the tree several times, or working the pump by hand. Even with this pump, however, tall trees cannot be readily reached, and to obtain more reliable and more constant power a *steam pump* is being constructed, which is guaranteed to carry three streams through the ordinary three-quarter-inch hose at one time, fifty feet high. This will enable the hose to be taken into tall ornamental trees, and the work to be done more effectually, economically and quickly than by any of the ordinary hand or machine pumps. The pump, engine and tank, holding one hundred to one hundred and fifty gallons, will be compactly mounted on a low truck, with wheels having six-inch tires and bolster springs, that it may be drawn over soft or rough ground with the least jolting possible. The weight of engine, pump, tank and truck is expected not to exceed eight hundred pounds, and when the tank is filled to be easily drawn by two horses.

Vegetables.

During the past season the following number of varieties of vegetables has been tested: —

Asparagus, 3 varieties; artichoke, 2; beans, 11; beets, 6; Brussells sprouts, 2; carrots, 6; cabbages, 8; cauliflowers, 5; celery, 10; cucumbers, 6; sweet corn, 7; dandelion, 2; endive, 2; kohl-rabi, 2; lettuce, 5; onions, 6; parsley, 2; peppers, 4; egg-plant, 6; peas, 7; pumpkins, 4; radishes, 6; squashes, 11; spinach, 3; parsnips, 6; tomatoes, 16; rhubarb, 4.

Seed Testing.

Seed testing is of the greatest practical importance to the farmer, market gardener and the florist, but at the same time it is most difficult so to conduct it as to obtain entirely satisfactory results. It will be hardly possible, with the present equipment, to make trial of the seeds of all of the varieties of farm and garden crops put upon the market by different

growers, and it is planned to procure only those that are most largely grown and the new promising kinds. In the outline for this work it is proposed to make at least three tests of each variety under each of several methods adopted in the greenhouse, and three in the field at different dates, yet under as nearly the same conditions as possible. It is also proposed to test the quality of the products of each under ordinary field culture. In this way it is hoped to arrive at some definite conclusions respecting the comparative value of each variety for general cultivation, and the dependence of the crop on the quality of the seed.

Plants in the Greenhouses.

In these houses most of the promising new varieties of plants grown by the commercial florist are tested as they are introduced. The following is a partial list of the number of varieties tested: —

Carnations, 18 varieties; chrysanthemums, 30; coleus, 14; begonias, 31; bulbs, 55 species and varieties; geraniums, 24; roses, 12; violets, 3, etc.

REPORT OF METEOROLOGIST.

LEONARD METCALF.

Aside from the mere routine work incident to keeping up the daily meteorological records and observations, the work of the department has been confined chiefly to the compilation of data accumulated at this observatory during the past seven years. The records of this station, from the time of its foundation in 1889 to date, have been compiled and summarized, and tables have been prepared showing the maximum, minimum and mean observations. These results will probably be published in the form of a special bulletin early next year.

But few new instruments have been added to our equipment, — one or two new clocks for the self-recording instruments replace the old ones in case of emergency or mishap, and thus preserve the continuity of the records; and a new signal service standard Fahrenheit thermometer, for comparing and verifying the accuracy of the temperature indications of the wet and dry bulb thermometers, and the maximum, minimum and self-recording thermometers.

The ozone observations have been discontinued, owing to their uncertainty and unreliability. The amount of rainfall will henceforth be recorded on top of the tower, as on the ground, by means of a United States signal service standard rain gauge (as well as by the self-recording gauge), in order that the tower readings may be perfectly comparable with those of the ground.

REPORT OF CHEMIST.

DEPARTMENT OF FOODS AND FEEDING.

Conducted by J. B. Lindsey, with the assistance of C. S. Crocker, B.S., chemist; E. B. Holland, B.S., chemist; G. A. Billings, B.S., assistant in feeding department.

Part I.

Laboratory Work.

(*a*) Fodder analyses.
(*b*) Water analyses.
(*c*) Dairy products.

Part II.

Feeding Experiments and Dairy Studies.

(*a*) Chicago gluten meal *v.* King gluten meal.
(*b*) Chicago gluten meal *v.* Atlas meal.
(*c*) Composition of cream from different cows.
(*d*) Wheat meal *v.* rye meal for pigs.
(*e*) Salt hays and meadow hay (values for feeding).

PART I.

(a) FODDER ANALYSES.

We have received and analyzed for farmers during the year 49 samples of various grains, by-products and coarse feeds. We publish here only those having any particular interest, or that have more recently appeared in our markets. For analyses of all such feeds see complete table at the end of this report.

All cattle feeds have been divided into five groups of substances : —

1. *Crude ash* means the mineral ingredients contained in the plant or seed, such as lime, potash, soda, magnesia, iron, phosphoric acid, sulphuric acid and silicic acid. The ash serves to build up the bony structure of the animal.

2. *Crude cellulose* is the coarse or woody part of the plant; straws and hays contain large quantities, while in the grains and most by-products but little is present. It serves to produce vital energy and fat.

3. *Crude fat* includes the fats, waxes, resins, etc. It serves the same purpose as cellulose, but furnishes two and one-half times as much vital energy.

4. *Protein* is a general name for all nitrogen-containing bodies found in plants. It might be called "vegetable meat." It is a source of energy, possibly a source of fat, and *is the only source of flesh.*

5. Nitrogen-free extract consists of starch, sugars and gums. These substances produce energy and fat. Cellulose and extract are termed carbohydrates.

The grains are valuable chiefly for their extract matter, protein and fat. They contain very little cellulose. The estimation of protein and fat is as a rule all that is necessary to enable one to judge whether or not they are of superior, average or inferior quality.

Many by-products contain as small amounts of crude cellulose as do the grains. Others, such as brans, dried brewers' grains, etc., have from 7 to 12 per cent.

An estimation of the protein and fat only is necessary to enable one to get at their comparative values. Such feeds are bought chiefly for their protein content.

One-fourth to one-third of coarse fodders — hays, straws, corn fodders — consists of crude cellulose. This cellular matter, in so far as it is digestible, is equal in value to the digestible extract matter. Coarse fodders naturally constitute the bulk of the feed for neat stock, and are valuable chiefly for their cellular and extract matter (carbohydrates).

Analyses.

(*a*) *Gluten Feeds.* — The gluten feeds are being sold very largely in Massachusetts markets at the present time. They consist of the skin or hull, the germ and the gluten of the corn kernel. The Pope gluten feeds do not contain the germ.

CONSTITUENTS.	Peoria.	Peoria.	Peoria.	Buffalo.	Pope (White).	Pope (Yellow).
Water (per cent.),	9.00	9.00	9.00	9.00	9.00	9.00
Crude ash (per cent.),	.91	-†	-†	.81	1.22	.99
" cellulose (per cent.),	7.69	-†	-†	7.10	6.04	6.35
" fat (per cent.),	11.72	13.07	11.04	11.92	7.39	7.21
" protein (per cent.),	17.45	21.51	22.00	23.40	25.12	24.60
Extract matter (per cent.),	53.23	-†	-†	47.77	51.23	51.85
	100.00	-	-	100.00	100.00	100.00

† Not determined.

These feeds are kiln dried, and contain from 7 to 10 per cent. of water. For the sake of comparison, they are all calculated to a uniform basis (9 per cent.). It will be noticed that the per cent. of protein varies from 17.5 to 25; *i. e.*, a 30 per cent. variation. The per cent. of fat also varies from 13.07 to 7.21; *i. e*, a 45 per cent. difference. These feeds, with such wide variations in protein and fat content, are sold practically at the same price per ton.

(*b*) *Oat Feeds.* — This material is being very largely offered. It consists of oat hulls, poor oats and the refuse from oat-meal factories, mixed with more or less ground

barley, bran, inferior corn meal, etc. It is sold under a variety of names, such as oat feed, Quaker oat feed, corn and oat chop, etc.

CONSTITUENTS.	Oat Feed.	Corn and Oat Chop	Quaker Oat Feed.	Oat Feed.	Oat Feed.
Water (per cent.),	10.00	10.00	10.00	10.00	10.00
Crude ash (per cent.),	4.47	3.60	4.87	-†	3.73
" cellulose (per cent.),	15.13	11.62	14.68	14.88	11.76
" fat (per cent.),	3.64	4.11	3.68	3.73	4.23
" protein (per cent.),	10.70	10.69	12.33	11.32	10.18
Extract matter (per cent.),	56.06	59.98	54.44	-†	60.10
	100.00	100.00	100.00	-	100.00

† Not determined.

We cannot commend this article to farmers. It is made up of different materials, and in putting it upon the market the manufacturer simply is enabled to work off inferior articles and refuse. It of course has considerable feeding value, but the several ingredients can be bought cheaper in other materials, such as corn meal, gluten feed, etc.

(*c*) *Gluten Meal.* — This feed stuff is prepared from the hard, flinty portion (gluten) of the corn.

Since July the attention of the station has been frequently called to the difference in the appearance of the Chicago gluten meal. It formerly had a golden yellow color. A portion of that now appearing on the market has a light or grayish appearance. The manufacturers claim that this is due to the use of white corn.

CONSTITUENTS.	Chicago.						Pope Gluten Meal.
	OLD PROCESS.	IMPROVED PROCESS.					
	Yellow.	White	White.	White.	Yellow.	Yellow.	
Water (per cent.),	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Crude ash (per cent.),	.90	1.19	-†	-†	-†	-†	.58
" cellulose (per cent.),	1.10	3.39	-†	-†	-†	-†	1.72
" fat (per cent.),	6.20	6.02	7.20	6.51	6.59	6.93	7.55
" protein (per cent.),	30.50	38.39	38.77	37.41	38.96	42.21	36.60
Extract matter (per cent.),	52.30	42.01	-†	-†	-†	-†	44.55
	100.00	100.00	-	-	-	-	100.00

† Not determined.

The analyses of the so-called improved Chicago meal show it to contain a higher per cent. of protein than the old-process meal contained. The manufacturers claim that this is due to a more complete removal of the starch. Both the white or light and yellow meal have practically the same composition, and are consequently equally valuable for feeding.

(*d*) *Brans and Rice Meal.*

CONSTITUENTS.	Rex Bran.	Cotton-seed Meal Bran.	Cotton-seed Hull Bran.	Rice Meal.
Water (per cent.),	11.00	11.00	11.00	10.00
Crude ash (per cent.),	3.35	2.87	1.93	8.40
" cellulose (per cent.),	18.74	28.60	34.99	5.63
" fat (per cent.),	2.71	3.89	1.09	13.17
" protein (per cent.),	8.90	10.50	2.34	11.59
Extract matter (per cent.),	55.30	43.14	48.65	51.21
	100.00	100.00	100.00	100.00

The above brans are all much inferior to the average wheat bran. The rice meal is a good average sample of its kind, and possesses a feeding value similar to corn meal. Experiments are now in progress with this meal.

(b). WATER ANALYSIS.

To determine the healthfulness of a water for drinking, the object is to note the quantity, kind and condition of the organic matter, as well as the total amount of mineral constituents it contains.

All water contains more or less mineral matter in solution, derived from the soil through which it percolates. Moderate quantities (see limit below) are beneficial, and impart to the water a pleasant taste.

The method employed at this laboratory for testing waters is what is known as Wancklyn's process. This chemist interprets the results of his mode as follows: —

1. More than 71 parts per million of chlorine, accompanied by more than .08 part per million of free ammonia and more than .10 part per million of albuminoid ammonia, indicate that the water is polluted with sewage, decaying animal matter, urine, etc. (The amount of chlorine in water depends somewhat on the section of the State from which it comes.)

2. Total solids should not exceed 571 parts per million.

3. Water showing less than 5 degrees as here expressed is termed soft; between 5 and 10 degrees, medium; and above 10 degrees, hard.

"Albuminoid" ammonia is the ammonia derived from the breaking up of vegetable or animal matter in water, as a result of the action of certain chemicals in the process of analysis. Its presence indicates, therefore, that the water contains these matters in solution.

The presence of free or actual ammonia in water shows that these animal or vegetable substances are being decomposed by various bacterial growths. Much free ammonia is an indication that a water is suspicious or even dangerous for drinking.

Chlorine is one of the two components of common salt, and salt is always found both in the urine of human beings

and in that of domestic animals, as well as in many waste waters. Excess of chlorine would therefore make it clear that a water contained sewage of some kind.

It is impossible, from a chemical analysis, to say whether or not a water is contaminated with the specific germ of any contagious disease. This is the work of the bacteriologist.

Character of Waters tested.

We have tested for farmers during the year 124 samples of water. Of these, 81, or 65.3 per cent., were found safe; 18, or 14.5 per cent., rather suspicious; and 25, or 20.2 per cent., dangerous for drinking. Five samples contained very noticeable quantities of lead derived from the lead pipe through which the waters flowed. Soft waters are especially liable to take up the lead. Every one is cautioned against the use of lead pipes, as waters containing this substance are very injurious to the health.

Sample Analyses of Different Waters.

Quality of Water.	Parts per Million.					Clark's Degrees.
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Total Solid Matter.	Mineral Solids.	Hardness.
Excellent,	–*	.04	5.00	70.0	46.0	–†
	.02	.07	3.00	70.0	32.0	1.43
	.01	.03	4.00	–†	–†	5.43
Good,	.01	.10	19.00	104.0	54.0	3.25
	.02	.12	7.00	–†	–†	1.11
	.04	.06	8.00	–†	–†	1.26
Suspicious,	.08	.07	18.00	–†	–†	–†
	.04	.11	38.00	336.0	186.0	10.15
	.04	.20	22.00	–†	–†	–†
Dangerous,	.16	.14	35.00	–†	–†	5.71
	.20	.08	22.00	–†	–†	–†
	.26	.48	2.00	84.0	22.0	2.47

* None. † Not determined.

It was not considered necessary to publish the analysis of each water analyzed during the year.

Instructions for sampling and sending Water.

In dipping water from springs or drawing it from open wells, be sure that no foreign material falls into it. Do not take a sample from water that has stood in a pump for any length of time. Send at least two quarts, in *an absolutely clean* vessel. Waters received in dirty vessels are not tested, as the results would be of no value. A clean new stone or earthen jug is to be preferred.

Answer briefly the following questions in regard to the water: —

1. Is it well, shallow spring or hydrant water?
2. Do you suspect it to be the cause of any contagious disease?
3. Do you suspect lead poisoning?
4. What is the character of the ground through which it percolates?
5. How far is the well from house or barn?

(c) DAIRY PRODUCTS.

MILK, CREAM, ETC.

We have received and tested for farmers during the year 87 samples of milk, 18 samples of cream and 4 samples of butter; 24 samples of butter have also been analyzed for the Dairy Bureau. It is not considered necessary to publish these analyses here. They will be found tabulated at the end of the report.

INFORMATION.

Average cow's milk has approximately the following percentage composition: —

	Per Cent.		Per Cent.
Water,	87.0	Albumen,	.50
Fat,	3.7	Milk sugar,	5.10
Casein (curd),	3.0	Ash,	.70

For practical purposes, we generally estimate the percentage of total solids (which includes everything except water) and fat.

For convenience, the Massachusetts milk standard for 1895, as well as the average composition of cream, skim and butter milks, follow: —

CONSTITUENTS.	Massachusetts Standard.	SKIM-MILK. Deep Setting.	SKIM-MILK. Separator.	CREAM. Deep Setting.	CREAM. Separator.	Butter-milk.
Total solids (per cent.),	13.00*	9.50	–	26.5	–	8.33
Milk fat (per cent.),	3.70	.32	.10	18.0	25.-35.	.27
Solids not fat (per cent.),	9.30	–	–	–	–	–

* During May and June, 12 per cent.

Instructions for sending Milk.

Milk or cream should be sent by morning express, if possible. It should be marked "Immediate Delivery," and should not be sent later than Thursday of each week. Send one pint of milk and one-half pint of cream, preferably in Lightning or Mason fruit jars. *Be sure the vessels are perfectly clean.* Mix the milk or cream thoroughly before taking the sample, by pouring from one vessel to another.

Part II.

(*a*) CHICAGO GLUTEN MEAL *v.* KING GLUTEN MEAL.

Experiment with Cows.

Object of the Experiment.

The object of the experiment was to compare the relative merits of the two gluten meals for milk production.

Chicago Meal. — The general character and appearance of this meal is well known.

King Meal. — This meal is very probably a by-product from corn, the process of manufacture being somewhat different from that employed in case of the Chicago meal. It contains apparently no husks or germs; the fat from the germ, however, is present, making the meal very rich in this latter substance. For the sake of comparison the composition of the two meals is given below: —

CONSTITUENTS.	Chicago.	King.
Water (per cent.),	9.33	7.34
Crude ash (per cent.),	.13	1.38
" cellulose (per cent.),	1.57	1.30
" fat (per cent.),	4.17	18.48
" protein (per cent.),	33.64	35.57
Extract matter (per cent.),	51.17	35.93

Plan of the Experiment.

Four grade cows were employed, in different stages of lactation. The preliminary feeding period lasted seven days, and the feeding period proper seven days. All other feeds

excepting the two gluten meals remained constant during the experiment. The data will be found in Table I. The following method was employed to overcome the natural milk shrinkage. The cows were divided into two lots. During the first period cows I. and III. received the King meal, at the same time cows IV. and VI. were receiving the Chicago meal; during the second period this order was reversed. This experiment was in operation during June, 1894. The cows were allowed the run of the barn-yard during the day, and so far as possible all conditions were identical during the entire time.

TABLE I.

PERIODS.	Number of Animals.	Length of Feeding Period (Days).	Average Live Weight (Pounds).	AVERAGE DAILY RATIONS. TOTAL. Wheat Bran (Pounds).	King Gluten Meal (Pounds).	Chicago Gluten Meal (Pounds).	Rowen (Pounds).	DIGESTIBLE. Protein (Pounds).	Carbohydrates (Pounds).	Fat (Pounds).	Total (Pounds).	Nutritive Ratio.
King, .	4	10	935	4.5	4.5	-	18	3.30	9.65	1.15	14.1	1:3.8
Chicago, .	4	10	937	4.5	-	4.5	18	3.16	10.49	.56	14.2	1:3.7

TABLE II. — *Average Yield and Cost of Milk.*

PERIODS.	Total Cost of Feeds (Dollars).	Total Yield of Milk (Quarts).	Average Daily Yield per Cow (Quarts).	Cost of Milk per Quart (Cents).
King, ...	$6 61	318.4	11.36	2.08
Chicago, ...	6 61	314.4	11.23	2.10

Comments on the Results.

Table I. shows that the cows consumed the same amount of digestible matter daily in each period.

Table II. shows that the daily yield of milk and the cost per quart were practically identical in each period.

The Chicago meal was in its usual good condition. In spite of the fact that the King meal contained nearly 20 per

cent. of fat, no rancid odor or taste was noticed after the meal had been in the barn six months. Its mechanical condition was all that could be desired. The objection to feeding by-products especially rich in fat is that, if they are fed alone in large quantities (above 3 quarts daily) or fed in combination with other material of a similar nature, the tendency is to cloy the appetite of the animal, or — in warm weather especially — to produce inflammation of the milk glands.

In a daily grain ration of 9 pounds we would not advise feeding over 3 or 4 pounds of but one by-product having above 7 to 8 per cent. of fat.

The principal criticism on this experiment would naturally be the shortness of its feeding periods. This could not have been well avoided. The results obtained, however, are, it is believed, sufficient to give one an idea of the comparative value of the two grains.

(b) CHICAGO GLUTEN MEAL v. ATLAS MEAL.

Experiment with Cows.

Object of the Experiment.

The experiment was undertaken for the purpose of noting the feeding value of the new by-product Atlas meal, as compared with Chicago gluten meal.

Atlas Meal. — This is a comparatively new article in Massachusetts markets. It consists of the hull, gluten and germ of different grains left behind in the process of alcohol manufacture. It comes into the market ground fairly fine, and contains about the same amount of protein as does the Chicago meal. The amount of cellulose and fat is, however, in excess of the latter. The composition of the two grains follows: —

CONSTITUENTS.	Chicago.	Atlas.
Water (per cent.),	9.00	10.00
Crude ash (per cent.),	.13	.37
" cellulose (per cent.),	1.57	10.75
" fat (per cent.),	4.18	13.75
" protein (per cent.),	33.75	33.57
Extract matter (per cent.),	51.37	31.56

Plan of the Experiment.

The experiment was in operation during January and a part of February, 1895. The cows, four in number, were grades. The feeds consisted of hay, corn and soja-bean ensilage, bran, Chicago gluten meal and Atlas meal. The ensilage, hay and bran remained constant during the entire experiment. The preliminary feeding periods lasted seven days, the two periods proper ten days each. To overcome the natural milk shrinkage the following arrangement was instituted. The cows were divided into two lots. In Period I., cows 3 and 6 were fed Chicago meal at the same time

that cows 4 and 5 were receiving Atlas meal. In Period II. this order was reversed. The cows were kept in the barn during the entire experiment, and were treated precisely alike during both periods. Two composite samples (three days each) of milk were tested during each period. The tables following give the average results from the four cows: —

TABLE I.

PERIODS.	Number of Animals.	Length of Feeding Periods (Days).	Average Live Weight (Pounds).	Average Daily Rations. Total. Wheat Bran (Pounds).	Chicago Meal (Pounds).	Atlas Meal (Pounds).	Corn and Soja-bean Ensilage (Pounds).	Hay (Pounds).	Digestible. Protein (Pounds).	Carbohydrates (Pounds).	Fat (Pounds).	Total (Pounds).	Nutritive Ratio.
Atlas, . .	4	10	943	4	-	4	42.1	5	2.46	9.15	1.17	12.78	1:4.9
Chicago, .	4	10	944	4	4	-	40.6	5	2.62	9.38	.84	12.84	1:4.4

TABLE II. — *Average Yield and Cost of Milk and Butter Fat.*

PERIODS.	Total Cost of Feed (Dollars).	Total Yield of Milk (Quarts).	Average Daily Yield per Cow (Quarts).	Cost per Quart (Cents).	Total Amount of Butter Fat (Pounds).	Total Cost of Butter Fat per Pound (Cents).
Atlas, . . .	$7 40	420.7	10.52	1.76	40.57	18.24
Chicago, . .	7 56	423.3	10.58	1.79	40.17	18.82

TABLE III. — *Average Composition of Milk.*

NUMBER OF COW.	Per Cent. Solids. Atlas.	Per Cent. Solids. Chicago.	Per Cent. Fat. Atlas.	Per Cent. Fat. Chicago.
3, ...	14.13	14.33	4.22	4.72
4, ...	13.86	13.65	4.88	4.60
5, ...	13.38	13.16	4.17	4.12
6, ...	14.33	13.71	4.52	4.06
Average, ...	13.93	13.71	4.45	4.38

Results.

The cost and quantity of milk and butter fat are so nearly equal in each case as to be considered practically identical. If the quality of the Atlas meal is maintained, it can be regarded as an excellent food for milch cows and neat stock in general.

(c) WHAT CONSTITUTES A "SPACE" OF CREAM.

J. B. LINDSEY AND GEO. A. BILLINGS.

In the report of the State Experiment Station for 1894 it was shown that the butter fat in the cream gathered from 165 different farmers varied from 11 to 22 per cent. Such figures only serve to emphasize the unreliability of the "space" as a basis for payment.

During the past autumn we have tested the cream raised by the deep-setting process from each of the six cows belonging to the station. The conditions were precisely alike in each case, the milk being immersed for the same length of time, and the temperature of the water maintained at 38 to 40 degrees. The cows were all fresh in milk, having calved from one to two months previously.

History of the Cows.

Cow I., grade Ayrshire, six years old, weighing 800 pounds, yielding about 4 per cent. fat in milk.

Cow II., native, nine years old, weighing 900 pounds, yielding 4 per cent. fat in milk.

Cow III., grade Ayrshire-Jersey, seven years old, weighing 850 pounds, yielding 4.2 per cent. fat in milk.

Cow IV., grade Jersey, six years old, weighing 1,050 pounds, yielding 5 per cent. fat in milk.

Cow V., grade Durham, seven years old, weighing 1,050 pounds, yielding 3 per cent. fat in milk.

Cow VI., grade Durham-Jersey, about seven years old, weighing 1,000 pounds, yielding 5 per cent. fat in milk.

Table I. shows the daily results and the average for the three days (two days in case of cows V. and VI.).

TABLE I.

NUMBER OF COW.	Number of Days.	Milk per Day (Pounds).	Spaces Cream per Day.	Per Cent. of Fat in Cream.	Per Cent. of Fat in Skim-milk.
I., . . .	1, ...	25.90	8.10	16.90	.20
	1, ...	26.00	7.50	16.60	.15
	1, ...	25.50	7.80	16.10	.17
	Average, .	25.80	7.80	16.53	.17
II., . . .	1, ...	21.50	5.30	16.15	.55
	1, ...	22.00	5.50	15.90	.57
	1, ...	22.75	5.90	17.30	.55
	Average, .	22.08	5.57	16.45	.56
III., . . .	1, ...	25.50	11.50	11.20	.25
	1, ...	26.87	10.80	12.05	.30
	1, ...	26.50	11.60	12.70	.25
	Average, .	26.30	11.30	11.98	.27
IV., . . .	1, ...	25.95	8.10	21.00	.18
	1, ...	27.12	8.40	21.45	.20
	1, ...	25.00	8.10	22.65	.13
	Average, .	26.02	8.20	21.70	.17
V., . . .	1, ...	28.00	7.00	15.70	.17
	1, ...	30.63	7.10	16.20	.15
	Average, .	29.31	7.05	15.95	.16
VI., . . .	1, ...	31.12	10.90	20.25	.15
	1, ...	31.50	8.80	19.45	.13
	Average, .	31.31	9.85	19.85	.13

TABLE II. — *Showing the Results on the Basis of 25 Pounds of Milk per Cow.*

NUMBER OF COW.	Spaces of Cream.	Per Cent. of Fat in Cream.	NUMBER OF COW.	Spaces of Cream.	Per Cent. of Fat in Cream.
I., . . .	7.56	16.53	IV., . . .	7.89	21.70
II., . . .	6.30	16.45	V., . . .	6.01	15.95
III., . . .	10.74	11.98	VI., . . .	7.87	19.85

Cows I., II. and V. produced the smallest number of spaces of cream, containing 16 to 16½ per cent. of fat. Cow III. produced nearly 11 spaces of cream with 12 per cent. of fat. Cows IV. and VI. produced nearly 8 spaces of cream each, containing from 20 to nearly 22 per cent. of fat.

According to the present system, cream is paid for at the same price per space, whether it contains 12, 16 or 22 per cent. of butter fat, *i. e.*, whether equal quantities of such cream will produce 12, 16 or 22 pounds of butter. Under this system a farmer with a herd of extra butter-producing cows, yielding cream by the deep-setting process, containing 19 to 22 per cent. of fat, receives no more money than another farmer who produces a like quantity of cream testing but 15 or 16 per cent. of fat. *The injustice must be apparent* to every thinking farmer. The investigation, as shown in the above tables, might have been carried still further by weighing the cream, calculating the *amount* of butter fat produced, and seeing how much butter a given number of spaces of each cow's cream would produce. This was done, however, in last year's investigation, and, at the risk of repetition, the summary of the results bearing on this point is presented in Table III. Our object in the present experiment has been simply to show how the per cent. of fat in the cream of six individual cows varied under exactly similar conditions.

TABLE III. — *Summary of Results obtained in 1894 with Cream gathered from 165 Farmers, showing Butter Equivalent from 100 Spaces of Graded Cream, and Value of Same.*

Pounds of Butter Fat from 100 Spaces of Cream.	Number of Patrons.	Per Cent. of Patrons.	Equivalent to Butter (Pounds).	Value of Butter at 25 Cents per Pound.
8-12, ...	10	6.1	13.42*	$3 35
12-13, ...	23	14.0	14.58	3 64
13-14, ...	52	31.5	15.75	3 94
14-15, ...	41	24.9	16.92	4 23
15-16, ...	30	18.2	18.08	4 52
16-18, ...	9	5.5	19.83	4 96

* Figured on the basis of 11.5 pounds of butter fat.

A full explanation of the Babcock system (by which the farmer is paid for the number of pounds of butter fat actually furnished by him), and how to put it into practical operation, has already been published.* This system offers encouragement for every one to improve his herd by weeding out the unprofitable cows and putting in their places only those that will produce good yields of rich milk.

Under the space system those farmers having extra cows that are well taken care of simply help out their shiftless neighbors who keep inferior animals. That the latter class of farmers is glad to be thus aided, and is as a rule opposed to any change, is not to be wondered at. How long the more thrifty, painstaking farmers will be willing to continue this, is a question for them to decide.

* "Creamery Practice," by J. B. Lindsey, published by Dairy Bureau, 20 Devonshire Street, Boston, Mass.

(*d*) WHEAT MEAL *v.* RYE MEAL FOR PIGS.

Object of the Experiment.

In this experiment it was intended to compare the feeding values of wheat and rye meal, when fed in combination with skim-milk to growing pigs.

Plan of the Experiment.

The pigs were divided into two lots, two barrows and a sow being in each lot. The experiment was divided into three periods, covering in all 106 days. It was intended, in the first period, to feed 3 ounces of meal to each quart of milk, but the supply of milk being limited, some Peoria gluten feed was added to keep the ratio of protein to carbohydrates as 1 to 3.5.

In the second period 4 quarts of milk were fed daily, together with sufficient wheat or rye meal to satisfy appetites.

In the third period 4 quarts of milk were fed daily, in connection with equal parts of wheat or rye meal and corn meal to satisfy the appetites of the animals. Sufficient water was added to the milk and meal to furnish the necessary amount of liquid. The pigs were fed three times daily.

Table I. — *Feeding Plan.*

PERIOD.	Number of Days.	Feed.	Nutritive Ratio.
I., . .	58	3 ounces wheat or rye meal to each quart of milk, . .	1:3.6
II., . .	13	4 quarts milk daily, and wheat or rye meal to satisfy appetites.	1:4.0
III., . .	35	4 quarts milk, and equal parts wheat or rye meal and corn meal to satisfy appetites.	1:5.3

Table II. — *Average Daily Gain (Pounds).*

LOT.	Period I.	Period II.	Period III.	Total Average Daily Gain.
I., wheat, ...	1.06	1.21	1.49	1.22
II., rye, ...	1.00	1.15	1.20	1.10

TABLE III. — *Total Feed consumed.*

LOT I. (WHEAT).

PERIODS.	Skim-milk (Quarts).	Wheat Meal (Pounds).	Peoria Feed (Pounds).	Corn Meal (Pounds).	Nutritive Ratio.
I.,	744.0	205.1	73.5	-	1:3.6
II.,	195.0	114.0	-	-	1:4.0
III.,	450.0	212.5	-	212.5	1:5.2
Total,	1,389.0	531.6	73.5	212.5	-
Equal to dry matter,	283.7*	468.0	68.3	180.6	-

* Pounds.

LOT II. (RYE).

PERIODS.	Skim-milk (Quarts).	Rye Meal (Pounds).	Peoria Feed (Pounds).	Corn Meal (Pounds).	Nutritive Ratio.
I.,	744.0	205.10	73.5	-	1:3.8
II.,	195.0	114.00	-	-	1:4.4
III.,	450.0	183.75	-	183.75	1:5.4
Total,	1,389.0	502.80	73.5	183.75	-
Equal to dry matter,	283.7*	432.40	68.3	156.20	-

* Pounds.

TABLE IV.

	Lot I.	Lot II.
Average live weight at beginning of experiment (pounds),	33.33	34.20
Average live weight at end of experiment (pounds),	162.70	150.00
Average gain of each pig (pounds),	129.37	115.80
Average daily gain (pounds),	1.22	1.10
Dry matter required to produce 1 pound live weight (pounds),	2.58	2.71
Skim-milk actually returned per quart (fraction of cent),	.65	.55
Cost of feed for each pound of live weight gained (cents),*	4.25	4.58
Price received per pound of live weight (cents),	4.80	4.80

* On basis of following prices for feed: skim-milk, 2 cents per gallon; wheat and rye, $24 per ton; Peoria gluten feed, $21 per ton; and corn meal, $23 per ton.

Comments on Results.

Both lots of pigs made very fair gains, and the results as a whole compare favorably with other experiments, when skim-milk was fed with other grains. The average daily gain was nearly 1¼ pounds, and the dry matter required to make 1 pound of live weight averaged 2.65 pounds. The skim-milk returned .6 of one cent per quart, and the live weight cost 4.37 cents per pound, allowing skim-milk to be worth one-half cent per quart, and the grains as noted. The wheat meal seemed to give rather better results, especially in the last period. During this latter period the pigs fed on the rye-meal ration were off feed a good deal of the time, and gained less in weight. If the experiment had been continued longer, the results would have been still more in favor of the wheat meal.

Suggestions for Feeding Wheat or Rye Meal.

With pigs weighing from 30 to 100 pounds, feed 3 to 6 ounces meal to each quart of milk; with pigs weighing from 100 to 175 pounds, feed skim-milk at disposal (4 to 6 quarts per pig), and equal parts of wheat or rye meal and corn meal to satisfy appetites.

(e) SALT HAYS AND MEADOW OR SWALE HAY.

A. — Digestibility.
B. — How to feed them.

Summary of Results.

(*a*) Black grass, high-grown salt hay, branch grass and low meadow fox grass are all valuable fodder articles. In the present experiment black grass contained more protein and showed a higher average digestibility, and is therefore superior to the other three hays. There is no wide difference, however. Timothy hay shows more total digestible organic matter, but is noticeably inferior to three of the salt hays in digestible protein. Black grass might be classed as but little inferior to average timothy hay. High-grown salt hay, branch grass and fox grass resemble each other very closely in feeding value.

(*b*) Salt hays at average market prices are decidedly cheaper to feed than English hay.

(*c*) Meadow or swale hay is a very inferior article. It contained 150 to 200 pounds less digestible matter than did the salt hays, and but 39 per cent. of digestible dry matter.

(*d*) Hays containing much less than 50 per cent. of digestible dry matter should be regarded as of very inferior quality.

A. — Digestibility.

At the request of the experiment station, farmers in the vicinity of Newburyport sent four samples of salt hay. It was the intention of the writer to analyze these hays and test their comparative digestibilities. The hays were named as follows : —

1. Black grass (fine, and of dark color; consisted almost exclusively of *Juncus bulbosus*).
2. High-grown salt hay.
3. Branch grass.
4. Low meadow fox grass.

The low meadow fox grass appeared to consist practically of what is also called rush salt grass (*Spartina juncea*), and both the high-grown salt hay and the branch grass were composed of this as a basis, mixed with more or less coarse grass, probably *Spartina stricta*, variety *glabra*. The branch grass contained rather more of the coarse material than did the high-grown salt hay.

A sample of meadow or swale hay was also obtained, through the kindness of Mr. Chas. J. Peabody of Topsfield, in which vicinity large quantities are cut yearly. This hay grows in the fresh-water meadows, and is composed of fresh-water grasses, sedges, brakes and wild flowers.

The digestion tests were made with sheep, because these animals are much easier to work with, and give at the same time similar results as do cows and steers.

How the Digestible Matter of a Feed is determined.

First ascertain the amount and composition of the feed consumed by an animal in a given length of time, also the amount and composition of the fæces or undigested portion excreted in the same time on the basis of dry matter. The difference between them will represent the amount of the various constituents of the food digested.

The percentages of the constituents digested are called the digestion coefficients.

TABLE I. — *Composition of Hays.*

[The analysis of each hay is given on the basis of 15 per cent. of water, for the sake of comparison.]

FODDER CONSTITUENTS.	Black Grass.	High-grown Salt Hay.	Branch Grass.	Low Meadow Fox Grass.	Meadow Hay.	Timothy Hay for Comparison.
Water, ...	15.00	15.00	15.00	15.00	15.00	15.00
Crude ash, ...	9.91	6.92	8.75	4.96	5.27	4.30
" cellulose, ...	22.78	22.45	22.50	22.58	26.40	28.40
" fat, ...	2.23	2.13	1.88	2.18	1.59	2.40
" protein, ...	8.08	6.36	7.03	6.06	6.77	6.30
Nitrogen-free extract matter,	42.00	47.14	44.84	49.22	44.97	43.60
	100.00	100.00	100.00	100.00	100.00	100.00

TABLE II. — *Showing Average Digestion Coefficients obtained with Two Sheep.*

FODDER CONSTITUENTS.	Black Grass.	High-grown Salt Hay.	Branch Grass.	Fox Grass.	Meadow Hay.	Timothy Hay for Comparison.
Total dry substance,	59.5	53.0	56.0	53.0	39.0	58.0
Crude cellulose,	60.5	50.0	52.0	51.0	33.0	53.0
" fat,	41.5	47.0	32.0	24.0	44.0	61.0
" protein,	63.0	63.0	62.5	57.0	34.0	48.0
Nitrogen-free extract matter,	57.0	53.0	54.0	52.0	46.0	63.0

TABLE III. — *Showing Pounds of Digestible Organic Matter in 2,000 Pounds of the Several Hays, assuming Each Hay to contain an Average Amount of Water (15 Per Cent.).*

FODDER CONSTITUENTS.	Black Grass.	High-grown Salt Hay.	Branch Grass.	Fox Grass.	Meadow Hay.	Timothy Hay for Comparison.
Crude cellulose,	275.6	224.4	234.0	230.2	174.24	301.00
" fat,	18.5	20.0	12.0	10.4	14.03	29.28
" protein,	101.8	80.0	87.8	69.0	46.02	60.40
Extract matter,	479.8	499.6	484.2	511.8	413.72	549.36
Total,	875.7	824.0	818.0	821.4	648.06	940.04

The teachings of the above tables will be found summarized at the beginning of the article. The writer has hesitated about making too sharp distinctions between the several kinds of salt hay, in view of the fact that he has worked with but one sample of each kind. It is well known that late-cut hays are inferior in per cent. of protein and less digestible than early-cut hays; and the writer has no means of knowing with certainty, either from the appearance of the samples or otherwise, whether or not they were cut at the same stage of growth. Very few blossoms were to be found indicative of an early cutting. It is also recognized that the condition and situation of the land exert an influence upon the quality of the hay. On the other hand, the hays were selected by men practically familiar with such material, and pronounced fair samples of their kind.

B. — How to feed Salt and Meadow Hays.

(a) *Salt Hays.*

Only general directions can be given. First, these hays, having a value approaching an average English hay, can be fed in place of the latter article in so far as composition and digestibility (*i. e.*, quality) are concerned. In the second place, however, the amount of salt they contain will exert a controlling influence on the quantity that the animal can consume. The per cent. of salt in the four samples received was as follows: —

	Black Grass.	High-grown Salt Hay.	Branch Grass.	Fox Grass.	Average English Hay.
Per cent. salt,	6.35	3.20	4.09	2.51	1.50

This per cent. would probably vary from time to time, depending on the frequency with which the salt water came in contact with the meadows, etc. Should black and branch grasses contain on an average as much salt as found in the present case, it would hardly seem wise to feed over one-third to one-half of these grasses in the entire coarse fodder ration, while in case of the high-grown salt hay and the fox grass two-thirds to even the entire coarse fodder ration could consist of these hays. The experience of practical feeders can and has undoubtedly solved this problem. The majority of farmers will probably prefer to feed about one-half salt hay and one-half English hay or other coarse material.

Coarse fodders can for practical purposes be fed *ad libitum; i. e.*, the animals can be given all they will consume. This can be left to the judgment of the practical feeder.

Grain Rations (on basis of milch cows of 1,000 pounds live weight). — The following rations are combined to go with the coarse fodders: —

I.	Pounds.	II.	Pounds.
Cotton-seed meal,*	100	Linseed meal,*	100
Wheat bran,	100	Pope or King gluten meal,*	100
Corn meal,†	100	Wheat bran,	200
Mix and feed 6 to 9 quarts daily.		Feed 7 to 9 quarts daily.	

III.	Pounds.	IV.	Pounds.
Chicago gluten meal,*	100	Gluten meal,	100
Wheat bran,	100	Corn meal,	100
Gluten feed,‡	100	Feed 6 quarts daily.	
Feed 6 to 9 quarts daily.			

V.	Pounds.
Cotton-seed meal,	100
Wheat bran,	100
Feed 8 quarts daily.	

* Cotton-seed meal, linseed meals and the various gluten meals can be substituted one for the other. Cotton-seed meal, King and Pope gluten meal, on account of the high percentage of fat they contain, should not be fed together in the same ration.

† Chicago maize feed, Buffalo and Peoria or other gluten feeds can be used interchangeably.

‡ Gluten feeds can usually be substituted for corn meal with good effect.

(b) *Meadow Hays (for Milch Cows of 1,000 Pounds Live Weight).*

Meadow hay, being of inferior nutritive value, must be supplemented with feed stuffs containing large amounts of digestible matter, — especially protein, — in order to secure good results.

Coarse Fodder Ration 1. — Feed all the meadow hay the animal will eat.

Grain Rations for above.

I.	Pounds.	II.	Pounds.
Corn meal,	200	Corn meal,	100
Cotton-seed meal,	100	Wheat bran,	100
Feed 9 quarts daily.		Cotton-seed meal,	100
		Feed 10 quarts daily.	

III.

	Pounds.
Wheat bran,	100
Gluten feed,	100
Feed 14 to 16 quarts daily.	

Coarse Fodder Ration 2. — About one-half English hay and one-half meadow hay, or about one-half corn ensilage (30 pounds) and all the meadow hay the animal will eat.

Grain Rations for Above.

I.		II.	
	Pounds.		Pounds.
Corn meal,	150	Wheat bran,	100
Cotton-seed meal,	100	Gluten feed,	100
Feed 7 quarts daily.		Feed 10 to 12 quarts daily.	

Remarks. — The writer questions the wisdom of a system of farming in which much labor is devoted to securing meadow hay for feeding to farm animals. The large amount of grain necessary to be fed in order to secure reasonably nutritive rations calls for a considerable outlay of money, which renders the various rations of doubtful economy.

The tendency of modern dairy farming is to raise crops containing more nitrogenous matter (protein), and thus reduce the amount of grain to be purchased.

To farmers who have been gathering and feeding large quantities of meadow hay the writer would make the following suggestions: —

In addition to English hay, raise annual crops, such as peas and oats, vetch and oats and Hungarian grass. Cut these for hay. Grow corn fodder and soja-bean fodder, and put into a silo in the proportion of two parts corn to one part soja beans. Such a system will give large amounts of nutritious winter feed, and will enable one to get along with one-half of the grain feed mentioned above.

How to purchase Grains.

In making up grain rations cost must be considered, and one should be familiar with the fluctuating market values of the several feed stuffs in order to make economical combinations. The following figures show the approximate commercial values of the different feeds, based on the amount of digestible protein they contain: —

Wheat bran,	$18 00	$14 00
Corn meal,	19 00	15 00
Wheat middlings,	21 00	16 00
Brewers' grains,	21 00	16 00
Malt sprouts,	23 00	18 00
Gluten and maize feeds,	28 00	22 00
Atlas meal,	31 00	24 00
Old-process linseed meal,	31 00	24 00
New-process linseed meal,	32 50	25 00
Gluten meals,	35 00	27 00
Cotton-seed meal,	35 00	27 00

The above figures do not express the relative physiological effect of the different grains, but show their comparative values in digestible protein after figuring the digestible carbohydrates and fat at a definite price. They can be used as guides in purchasing.

Compilation of Analyses of Fodder Articles and Dairy Products,

MADE AT

AMHERST, MASS.

1868-1896.

Prepared by C. S. Crocker.

A. Fodder Articles.

B. Fertilizing Ingredients in Fodders.

C. Dairy Products.

A. *Composition and Digestibility of Cattle Feeds.*

[Figures equal percentages or pounds in 100.]

NAME.	Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
I. Green Fodders.																			
Fodder corn,	33	74.90	1.21	5.2	.5	2.0	11.7	25.2	2.4	9.8	56.7	2.7	.40	1.1	8.7	25.2	1.8	5.2	42.0
Fodder-corn ensilage,	38	78.30	1.20	6.0	.8	1.9	11.8	27.7	3.8	8.7	54.4	4.1	.60	.9	7.9	18.8	3.0	4.5	36.4
Corn and soja-bean ensilage,	3	76.50	2.60	7.3	.9	2.5	10.2	31.2	4.0	10.5	43.5	-	-	-	-	-	-	-	-
Oat and pea ensilage,	1	38.02	5.70	19.4	2.4	8.5	26.0	31.3	3.9	13.7	41.8	-	-	-	-	-	-	-	-
Millet and soja-bean ensilage,	6	75.70	3.00	7.3	1.0	3.0	10.0	30.2	4.0	12.3	41.4	-	-	-	-	-	-	-	-
Millet ensilage,	3	73.80	2.40	7.5	.8	1.7	13.8	33.3	3.1	6.6	52.3	-	-	-	-	-	-	-	-
Sorghum,	6	82.60	1.20	4.6	.3	1.5	9.8	26.7	1.5	8.7	56.3	2.7	.20	.7	7.2	15.8	1.1	4.0	41.7
Common millet,	9	64.60	1.70	11.0	1.0	2.6	19.1	31.0	2.7	7.5	54.0	-	-	-	-	-	-	-	-
Japanese millet (white head),	3	75.20	1.20	8.5	.6	2.2	12.3	34.5	2.3	8.7	49.6	-	-	-	-	-	-	-	-
Japanese millet (red head),	6	72.70	1.70	8.8	.5	1.9	14.4	32.1	2.0	6.9	52.9	-	-	-	-	-	-	-	-
Panicum miliaceum,	1	69.40	1.70	8.2	1.2	1.8	17.7	26.8	3.8	6.0	57.8	-	-	-	-	-	-	-	-
Panicum crus-galli,	2	72.90	2.10	7.6	.7	2.7	14.0	27.9	2.5	9.7	52.2	-	-	-	-	-	-	-	-
Mochi millet,	3	62.60	2.60	9.5	.7	3.7	20.9	25.6	1.8	9.9	55.7	-	-	-	-	-	-	-	-

Green oats,	6	74.00	2.10	7.8	.8	3.6	11.7	30.0	2.9	13.9	44.0	4.4	.50	2.5	8.5	17.0	1.7	9.7	32.8
Green barley,	1	79.10	1.80	7.9	.6	2.7	7.9	37.8	2.9	13.1	37.5	4.4	.40	1.8	5.8	21.1	1.7	9.2	27.4
Green rye,	2	72.00	1.60	8.9	.6	2.1	14.8	31.8	2.2	7.5	52.8	5.0	.40	1.5	10.8	19.1	1.3	4.2	38.5
Timothy (*Phleum pratense*),	2	65.40	1.70	11.3	.7	3.2	17.7	32.9	2.0	8.5	51.3	6.3	.40	1.5	11.7	18.4	1.1	4.1	33.9
Hungarian grass,	2	74.20	2.10	7.0	.5	2.6	13.6	27.9	1.7	9.4	53.0	4.8	.30	1.6	.9	19.0	.9	5.8	35.0
Vetch and oats (1 part vetch, 4 parts oats),	1	79.20	1.90	6.3	.8	2.8	9.0	30.3	3.9	13.3	43.7	4.2	.20	1.7	4.9	20.0	.7	8.0	23.6
Vetch and oats (1 part vetch, 9 parts oats),	3	81.00	1.70	6.4	.5	1.9	8.5	33.6	2.5	10.1	44.8	-	-	-	-	-	-	-	-
Vetch and oats (equal parts of each),	1	82.00	1.70	5.4	.5	3.0	7.4	29.8	2.8	16.8	41.3	-	-	-	-	-	-	-	-
Barley and peas,	1	83.90	1.30	5.4	.5	2.2	6.7	33.5	3.0	13.4	41.8	3.2	.24	1.7	4.1	20.1	1.3	10.3	25.5
Oats and peas,	2	84.00	1.30	4.7	.5	2.4	7.1	29.4	2.8	15.1	44.4	2.8	.24	1.8	4.3	17.6	1.2	11.6	27.1
Horse bean,	1	84.80	.90	4.3	.4	2.5	7.1	28.2	2.3	16.7	47.0	-	-	-	-	-	-	-	-
Flat pea,	2	78.80	1.90	5.2	.9	6.1	7.1	24.3	4.1	29.0	33.5	-	-	-	-	-	-	-	-
Soja bean,	14	75.50	2.50	6.5	1.1	4.2	10.2	26.5	4.6	17.3	41.6	3.4	.30	2.9	6.7	14.0	1.4	11.9	27.5
Soja bean (early white),	4	69.80	3.90	6.7	.8	5.0	13.8	22.8	2.7	16.5	45.2	-	-	-	-	-	-	-	-
Soja bean (early green),	1	69.90	3.90	7.1	1.2	5.8	12.1	23.5	3.9	19.4	40.2	-	-	-	-	-	-	-	-
Soja bean (early black),	1	82.20	2.30	4.5	.6	2.9	7.5	25.1	3.4	16.2	42.4	-	-	-	-	-	-	-	-
Soja bean (medium black),	1	76.90	2.90	5.0	1.6	5.0	8.6	21.7	6.8	21.7	37.1	-	-	-	-	-	-	-	-
Soja bean (late),	4	74.00	3.50	5.5	.7	5.9	10.4	21.1	2.8	22.8	39.7	-	-	-	-	-	-	-	-
Bokhara clover,	3	78.80	2.10	6.3	.6	4.2	8.0	29.5	3.0	19.7	37.9	-	-	-	-	-	-	-	-
Kidney vetch,	1	80.80	2.60	2.9	.7	3.5	9.5	14.9	3.5	18.4	49.9	-	-	-	-	-	-	-	-
Serradella,	3	82.40	1.90	5.3	.4	2.6	7.4	30.1	2.4	15.0	41.5	2.7	.30	2.0	19.0	15.1	1.6	11.3	26.1
Prickly comfrey,	1	86.80	2.80	1.5	.3	2.3	6.3	11.0	2.1	17.5	48.3	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
I. Green Fodders — Concluded.																			
Spurry,	1	72.30	2.60	7.0	.1	2.9	14.1	25.4	3.9	10.3	51.1	-	-	-	-	-	-	-	-
White lupine,	1	85.30	.70	4.6	.4	2.7	6.3	31.2	2.4	18.7	42.7	-	-	-	-	-	-	-	-
Yellow lupine,	1	86.00	1.50	3.8	.3	2.5	5.9	27.1	1.9	17.8	42.1	-	-	-	-	-	-	-	-
Spanish moss,	1	60.80	1.10	12.7	1.0	1.8	22.6	32.6	2.5	4.5	57.7	-	-	-	-	-	-	-	-
II. Hay and Dry Coarse Fodders.																			
English hay (mixed grasses),	60	14.00	5.40	26.7	2.4	8.1	43.1	31.1	2.8	9.5	50.3	16.0	1.1	4.8	25.4	18.7	1.4	5.6	29.7
Canada hay,	4	14.00	4.60	28.1	2.1	6.1	44.9	32.7	2.5	7.1	52.2	14.6	1.2	2.9	32.9	19.0	1.7	3.9	32.9
Rowen of mixed hays,	15	17.00	5.90	22.2	3.0	10.5	41.2	26.8	3.6	12.7	49.7	14.2	1.1	7.1	27.2	17.2	1.2	7.9	32.8
Timothy hay,	6	14.00	4.20	28.3	1.9	8.5	44.1	32.9	2.2	8.7	51.3	14.7	1.1	4.1	27.8	19.1	1.3	4.9	32.3
Red-top hay (*Agrostis vulgaris* With.),	4	14.00	4.30	28.3	1.4	6.8	45.2	32.9	1.6	7.9	52.6	17.3	.7	4.1	28.0	20.1	.8	4.8	32.6
Kentucky blue-grass (*Poa pratensis* L.),	2	14.00	7.20	29.7	1.8	7.5	39.7	34.6	2.1	8.7	46.2	-	-	-	-	-	-	-	-
Orchard grass (*Dactylis glomerata* L.),	4	14.00	6.10	30.0	2.5	8.1	39.3	34.9	2.9	9.4	45.7	18.3	1.4	4.9	21.6	21.3	1.6	5.6	25.1
Meadow fescue (*Festuca pratensis* Huds.),	5	14.00	7.90	31.7	1.6	5.8	39.8	36.9	1.9	6.8	46.3	-	-	-	-	-	-	-	-

Perennial rye-grass (*Lolium perenne* L.), .	4	14.00	7.90	25.4	2.1	10.1	41.4	29.6	2.4	11.7	48.2	-	-	-	-	-	-	-	-
Italian rye-grass (*Lolium Italicum* A. Br.),	4	14.00	6.50	28.6	1.6	7.1	42.2	33.3	1.9	8.2	49.1	-	-	-	-	-	-	-	-
Hungarian grass, ...	1	14.00	4.90	27.5	1.9	8.2	43.5	32.0	2.2	9.5	50.6	18.7	1.2	4.9	29.1	21.8	1.4	5.7	33.9
Barn-yard grass, ...	1	14.00	8.60	29.0	1.7	13.1	32.9	33.7	2.0	15.3	38.2	18.2	1.0	8.1	21.7	21.2	1.2	9.5	25.2
Hay of black grass (salt), ...	2	16.00	7.70	24.4	2.4	6.8	41.6	29.1	2.9	8.1	49.5	14.6	1.0	4.3	23.3	17.5	1.2	5.1	27.7
High-grown salt hay, ...	1	16.00	7.00	22.2	2.1	6.3	46.6	26.4	2.5	7.5	55.5	11.0	1.0	4.0	24.7	13.2	1.2	4.7	29.4
Branch grass (salt), ...	1	16.00	8.80	22.3	1.8	7.0	44.4	26.5	2.2	8.3	52.8	11.5	.6	4.3	24.0	13.8	.7	5.1	28.5
Low meadow fox grass (salt), ...	1	16.00	5.40	22.3	2.2	6.0	48.6	26.6	2.6	7.1	57.9	11.4	.5	3.4	25.3	13.7	.6	4.0	30.1
Salt hay (variety unknown), ...	2	16.00	4.30	24.0	2.5	3.4	50.5	27.8	3.0	4.1	60.1	-	-	-	-	-	-	-	-
Vetch and oats (1 part vetch, 4 parts oats), .	1	14.00	7.60	26.1	3.3	11.4	37.6	30.3	3.9	13.3	43.7	17.2	.6	6.8	20.3	20.0	.7	8.0	23.6
Vetch and barley, ...	2	14.00	5.30	27.9	2.0	11.9	38.9	32.4	2.3	13.9	45.2	18.4	.4	7.1	21.0	21.4	.5	8.3	24.4
Low meadow or swamp hay, ...	2	14.00	5.80	26.7	1.9	7.1	44.8	31.1	2.2	8.3	52.1	8.8	.8	2.4	20.6	10.2	1.0	2.8	23.9
Millet, ...	6	16.00	4.30	28.0	1.8	6.5	43.4	33.3	2.1	7.8	51.7	-	-	-	-	-	-	-	-
Oats in bloom, ...	1	15.00	5.60	30.6	2.4	5.5	42.0	34.1	2.9	6.6	50.0	17.1	1.5	3.9	30.7	19.0	1.8	4.6	36.5
Oats in milk, ...	1	15.00	5.20	29.2	2.3	9.3	39.1	34.3	2.7	10.9	46.0	16.3	1.4	6.5	28.5	19.2	1.7	7.6	32.6
Oats, ripe, ...	1	15.00	5.30	30.9	2.2	5.2	41.6	36.3	2.6	6.1	48.9	-	-	-	-	-	-	-	-
Winter rye in bloom, ...	1	15.00	5.40	28.1	2.2	9.1	40.2	33.0	2.6	10.7	47.3	15.7	1.4	6.4	29.4	18.4	1.6	7.5	34.5
Barley in milk, ...	1	15.00	4.20	24.7	2.4	8.8	44.9	29.1	2.8	10.3	52.8	13.8	1.5	6.2	32.8	16.3	1.7	7.2	38.5
Dry corn fodder, ...	4	20.00	4.10	23.4	1.4	6.2	45.9	29.3	1.8	7.7	56.1	15.2	1.0	3.7	34.0	16.1	1.4	4.1	42.6
Corn stover, ...	30	20.00	4.70	28.3	1.1	5.9	40.4	34.9	1.4	7.4	50.5	18.9	.6	3.1	25.9	23.4	.7	3.8	32.3
Common buckwheat, ...	1	8.50	13.40	17.8	2.7	16.4	41.2	19.4	3.0	17.9	45.1	-	-	-	-	-	-	-	-
Silver-hull buckwheat, ...	1	8.90	9.30	24.7	2.4	11.1	43.6	27.1	2.6	12.2	47.9	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	Composition. Fresh or Air-dry Substance. Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Composition. Water-free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Digestibility. Fresh or Air-dry Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Digestibility. Water-free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
II. Hay and Dry Coarse Fodders—Con.																			
Japanese buckwheat,	1	5.70	11.70	33.9	2.1	10.2	36.4	36.0	2.2	10.8	38.6	-	-	-	-	-	-	-	-
Teosinte,	1	6.10	6.60	27.1	1.2	9.1	49.9	28.9	1.3	9.7	53.1	-	-	-	-	-	-	-	-
Mammoth red clover,	3	11.40	8.70	24.4	1.9	14.0	39.6	27.5	2.1	15.8	44.8	-	-	-	-	-	-	-	-
Alsike clover,	6	10.00	10.70	23.6	2.3	14.9	38.5	26.2	2.6	16.6	42.7	12.5	1.2	9.2	27.2	13.9	1.3	9.8	30.3
Medium red clover,	2	5.60	8.50	28.7	2.4	14.0	40.8	30.4	2.5	14.8	43.3	15.2	1.2	9.2	30.0	16.1	1.3	9.8	30.7
Ground clover (poultry feed),	1	14.80	7.40	28.3	2.0	12.6	34.9	33.2	2.3	14.8	41.0	-	-	-	-	-	-	-	-
Lucerne (alfalfa),	6	9.70	7.20	27.7	1.7	12.3	41.4	30.7	1.9	13.6	45.8	13.6	1.0	9.5	22.3	15.0	1.2	10.5	26.4
Sand lucerne,	1	8.80	8.80	19.4	2.4	14.9	45.7	21.3	2.6	16.3	50.2	-	-	-	-	-	-	-	-
Bokhara clover,	5	8.00	8.30	27.5	2.9	15.8	37.5	29.9	3.2	17.2	40.7	-	-	-	-	-	-	-	-
Blue melilot,	1	8.20	13.70	25.0	1.6	12.7	39.8	27.2	1.7	13.8	42.4	-	-	-	-	-	-	-	-
Sainfoin,	3	9.90	7.80	21.6	3.1	15.7	41.9	24.0	3.4	17.4	46.5	-	-	-	-	-	-	-	-
Sulla,	2	9.40	8.40	18.8	2.5	15.4	45.5	20.7	2.8	17.0	50.2	-	-	-	-	-	-	-	-
Hairy lotus,	2	11.50	7.30	17.5	2.6	13.1	48.0	19.8	2.9	14.8	54.2	-	-	-	-	-	-	-	-
Summer rape,	1	11.10	16.30	16.2	3.4	12.8	40.2	18.2	3.8	14.4	45.3	-	-	-	-	-	-	-	-

Winter rape,	1	10.10	20.00	11.1	2.8	13.7	42.3	12.3	3.1	15.2	47.0	-	-	-	-	-	-	-	-
Dwarf Essex rape,	1	7.70	14.90	17.5	3.5	11.9	44.5	19.0	3.8	12.9	48.2	-	-	-	-	-	-	-	-
Soja bean,	4	12.10	7.30	21.1	4.1	14.2	41.2	24.0	4.7	16.2	46.8	11.2	1.2	9.8	27.2	12.7	1.4	11.2	30.9
Cow pea,	3	9.60	8.40	19.6	3.7	15.5	43.2	21.7	4.1	17.1	47.8	8.4	1.9	10.1	28.6	9.3	2.1	11.1	30.3
Small pea,	1	5.80	5.90	31.0	1.4	15.6	40.3	32.9	1.5	16.6	42.7	-	-	-	-	-	-	-	-
Flat pea,	1	8.90	8.60	29.0	1.7	21.9	29.9	31.8	1.9	24.0	32.9	-	-	-	-	-	-	-	-
Serradella,	3	9.60	6.40	22.8	2.4	15.4	43.4	25.2	2.6	17.0	48.1	11.4	1.8	10.0	27.3	12.6	2.0	11.1	30.3
Hairy vetch,	1	7.40	7.80	29.5	1.1	18.2	36.0	31.9	1.2	19.6	38.9	-	-	-	-	-	-	-	-
Common vetch,	2	8.90	7.50	27.7	2.3	13.8	39.8	30.4	2.5	15.1	43.8	15.0	1.4	10.5	26.3	16.4	1.5	11.5	28.9
Scotch tares,	1	5.80	11.60	26.1	1.6	18.4	26.5	30.9	1.9	22.0	31.4	-	-	-	-	-	-	-	-
Vetch and oats (equal parts each),	2	9.40	8.20	27.7	2.6	15.4	36.7	30.6	2.9	17.0	40.4	-	-	-	-	-	-	-	-
Vetch and oats (proportion unknown),	3	11.70	6.80	28.9	2.7	8.5	41.4	32.7	3.1	9.6	46.9	19.1	.5	5.1	22.4	21.6	.6	5.8	25.3
Vetch, oats and horse bean,	1	10.20	9.30	27.0	2.4	17.0	34.1	30.1	2.7	18.9	37.9	-	-	-	-	-	-	-	-
Horse-bean straw,	1	9.10	8.70	37.6	1.4	8.9	34.3	41.4	1.5	9.7	37.8	14.7	.7	4.4	22.0	16.1	.8	4.8	24.2
Soja-bean straw,	3	11.40	6.40	37.6	1.9	4.9	37.8	42.4	2.2	5.5	42.7	14.3	1.1	2.5	24.9	16.1	1.3	2.8	28.2
White daisy (*Chrysanthemum*, etc.),	1	9.60	6.40	32.6	2.1	7.0	42.3	36.1	2.3	7.7	46.8	15.0	1.3	4.1	28.3	16.6	1.4	4.5	31.3
Dry carrot tops,	1	9.80	12.50	12.3	1.8	19.1	45.5	13.6	2.0	20.1	50.4	-	-	-	-	-	-	-	-
Wheat straw,	1	6.20	4.50	33.7	1.5	6.8	47.3	35.9	1.6	7.2	50.5	18.9	.5	1.2	20.3	20.1	.6	1.2	20.3
Barley straw,	2	10.00	5.10	34.1	2.6	6.9	42.3	36.8	2.9	7.7	47.0	19.1	1.1	1.4	22.8	20.6	1.2	1.5	25.4
Japanese millet (white head),	1	8.50	4.70	32.0	2.2	7.0	45.6	35.0	2.4	7.7	49.8	-	-	-	-	-	-	-	-
Japanese millet (red head),	1	8.90	3.10	36.0	1.5	5.3	45.2	39.5	1.7	5.8	49.6	-	-	-	-	-	-	-	-
Japanese millet hay,	1	18.30	6.90	25.7	1.8	3.7	43.6	31.4	2.2	4.5	53.5	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	Composition. Fresh or air-dry substance. Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Composition. Water-free substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Digestibility. Fresh or air-dry substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Digestibility. Water-free substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
II. Hay and Dry Coarse Fodders — Con.																			
Millet straw,	1	13.40	5.90	36.2	1.2	4.3	39.0	41.8	1.4	5.0	45.0	-	-	-	-	-	-	-	-
Straw (*Panicum crus-galli*),	1	12.60	4.70	31.4	2.1	5.3	43.9	35.9	2.4	6.1	50.2	-	-	-	-	-	-	-	-
Straw (*P. miliaceum*),	1	12.20	5.40	37.1	2.6	3.4	39.3	42.2	3.0	3.9	44.7	-	-	-	-	-	-	-	-
Straw (*P. Italicum*),	1	19.70	5.00	33.3	1.3	3.4	37.3	41.5	1.6	4.2	46.4	-	-	-	-	-	-	-	-
III. Roots, Bulbs, Tubers, etc.																			
Beets, red,	7	87.80	1.10	.7	.1	1.5	8.8	6.0	.9	12.3	72.2	.3	-	1.1	8.0	2.6	-	9.2	65.7
Beets, sugar,	12	85.40	.90	1.0	.1	1.6	11.0	6.6	.7	11.2	75.5	1.0	.05	1.1	10.0	6.6	.35	10.2	75.5
Beets, yellow fodder,	4	88.50	1.00	1.0	.2	1.3	8.0	8.1	1.4	11.7	69.3	.4	-	1.0	7.2	3.3	-	8.8	62.1
Mangolds,	5	87.90	1.20	.8	.1	1.4	8.6	8.5	1.0	9.5	71.0	-	-	1.1	7.8	-	-	7.1	64.6
Ruta-bagas,	3	89.10	1.10	1.3	.2	1.2	7.1	11.8	1.5	11.0	65.9	1.0	.10	1.0	6.7	8.7	1.20	8.8	62.6
Turnips,	5	89.60	.90	1.2	.2	1.1	7.0	11.7	1.8	10.6	67.4	1.2	.20	1.0	6.8	11.7	1.80	9.5	65.4
Carrots,	5	89.00	.90	1.1	.2	1.0	7.8	9.1	2.1	8.8	71.6	-	-	-	-	-	-	-	-

Parsnips,	1	80.40	1.50	1.5	.4	1.3	14.6	7.7	3.4	6.9	74.6	-	-	-	-	-	-	-	-
Potatoes,	14	81.00	1.00	.5	.1	1.9	15.5*	2.6	.5	10.0	81.5†	-	-	.8	14.1	-	-	4.4	74.2
Artichokes,	1	77.50	1.10	.9	.2	2.9	17.4	4.2	1.0	12.8	77.2	-	-	-	-	-	-	-	-
Japanese radish (*merinia*),	1	93.30	.70	.7	.1	.5	4.7	10.3	1.1	7.5	70.8	-	-	-	-	-	-	-	-
Japanese radish (*niyas-hige*),	1	92.60	.70	.7	.1	.5	5.4	9.9	1.0	6.5	72.7	-	-	-	-	-	-	-	-
IV. Grains, Seeds, Fruits, etc.																			
Corn kernels,	29	10.60	1.50	1.9	4.8	10.9	70.3	2.1	5.4	12.2	78.6	-	-	-	-	-	-	-	-
Sweet corn kernels,	1	12.00	1.40	2.1	8.4	11.1	65.0	2.4	9.6	12.6	73.8	-	-	-	-	-	-	-	-
Wheat kernels,	2	10.60	1.80	2.2	1.6	12.0	71.8	2.5	1.8	13.3	80.4	-	-	-	-	-	-	-	-
Oat kernels,	2	11.10	3.10	8.4	5.8	13.2	58.4	9.5	6.5	14.8	65.7	1.7‡	4.1	10.4	43.2	1.9	4.6	11.7	62.6
Broom-corn seed,	1	14.10	2.20	7.1	3.5	9.6	63.5	8.3	4.1	11.2	74.0	-	-	-	-	-	-	-	-
Soja beans,	4	13.00	5.10	5.0	17.2	31.2	28.5	5.7	19.8	35.9	32.8	3.6	14.8	28.4	21.7	4.0	17.0	32.7	24.9
Red adzinki beans,	2	15.90	3.50	3.9	.7	20.6	55.4	4.6	.8	24.5	65.9	2.8	.5	18.1	47.6	3.3	.6	21.6	56.7
Saddle beans,	1	12.40	5.40	4.2	14.5	13.2	50.3	4.8	16.6	15.1	57.3	-	-	-	-	-	-	-	-
Horse beans,	1	10.30	3.90	7.3	.9	26.9	40.7	8.1	1.1	30.0	56.5	5.2	7.7	23.7	37.8	5.8	.9	25.4	52.5
Millet seed,	3	13.30	2.60	7.7	3.7	11.4	61.3	8.9	4.3	13.2	70.6	-	-	-	-	-	-	-	-
Chestnuts,	1	44.90	1.50	1.4	8.0	7.3	36.9	2.5	14.5	13.3	67.0	-	-	-	-	-	-	-	-
Cranberries,	1	89.40	.20	1.2	.6	.5	8.1	11.6	5.6	4.4	76.4	-	-	-	-	-	-	-	-
Apples,	2	77.70	.70	1.5	.5	1.0	18.6	6.6	2.3	4.3	84.7	-	-	-	-	-	-	-	-

* Starch (14 determinations) = 12.9 per cent. † Starch (14 determinations) = 68.2 per cent. ‡ With horses.

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR-DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
V. Flour and Meal.																			
Corn meal,	38	13.60	1.40	1.8	3.3	9.5	70.4	2.1	3.8	11.0	81.5	-	3.0	5.7	65.5	-	3.5	6.6	75.6
Corn and cob meal,	37	10.50	1.40	6.7	3.7	9.0	68.7	7.5	4.2	10.0	76.7	3.1	4.2	5.4	59.6	3.4	4.5	6.0	67.5
Cooked feed (oats and corn),	1	5.50	3.80	8.2	5.0	14.0	63.5	8.7	5.3	14.8	67.2	-	-	-	-	-	-	-	-
Hominy meal,	4	10.00	1.10	29.6	.5	3.2	55.6	32.9	.6	3.6	61.7	-	-	-	-	-	-	-	-
Wheat meal,	1	11.50	2.00	2.9	2.0	12.1	69.5	3.3	2.2	13.7	78.6	-	-	-	-	-	-	-	-
Ground oats,	2	9.30	3.50	8.5	3.6	11.4	63.7	9.3	4.0	12.6	70.2	4.2	3.2	8.0	58.5	4.6	3.6	8.8	64.5
Ground barley,	5	13.10	2.40	5.7	1.9	11.3	65.6	6.5	2.2	13.0	75.5	2.8	1.7	7.9	60.4	3.2	2.0	9.1	69.5
Broom-corn meal,	1	13.50	2.10	6.9	3.5	9.7	64.3	8.0	4.1	11.2	74.3	-	-	-	-	-	-	-	-
Pea meal,	1	8.80	2.60	17.7	1.6	19.2	50.1	19.4	1.7	21.0	55.0	11.7	1.2	17.1	46.6	12.8	1.2	18.6	51.1
Peanut meal,	1	8.00	4.00	3.5	10.8	49.0	25.7	3.8	11.7	53.3	26.9	.8	9.5	44.6	23.6	.9	10.4	48.5	24.7
"Red Dog" flour,	1	9.70	1.90	1.4	4.4	22.6	60.0	1.5	4.9	25.0	66.5	-	-	-	-	-	-	-	-
Bean meal,	1	12.00	1.40	2.1	8.5	11.0	65.0	2.4	9.6	12.6	73.8	1.5	7.3	9.7	60.4	1.7	8.3	10.9	68.6

VI. By-products and Refuse.

Linseed meal, old process,	8	9.70	6.20	7.8	6.6	33.1	36.6	8.6	7.3	36.7	40.5	4.4	5.9	29.5	28.6	4.9	6.5	32.7	31.6
Linseed meal, new process,	8	8.30	5.90	8.5	2.9	36.1	37.3	9.3	3.2	39.4	41.7	6.3	2.7	30.7	32.1	6.8	3.0	33.5	35.9
Cotton-seed meal,	32	8.00	6.90	6.84	10.74	41.62	25.9	7.44	11.68	45.24	28.11	2.2	10.0	36.6	16.54	2.38	10.86	39.8	18.0
Cotton-seed bran,	2	9.80	3.10	28.5	3.4	10.6	44.6	31.6	3.8	11.8	49.4	-	-	-	-	-	-	-	-
Wheat bran,	49	10.60	6.80	9.8	4.5	16.1	52.2	10.9	5.0	18.0	58.5	2.2	3.2	14.0	40.4	2.4	3.6	14.0	40.4
Spring wheat bran,	4	10.40	5.70	10.5	5.0	16.0	52.4	11.7	5.6	17.9	58.4	2.5	3.8	12.8	36.6	2.8	4.2	14.3	40.9
Winter wheat bran,	3	11.00	6.00	8.5	2.8	15.1	56.5	9.6	3.2	17.0	63.3	2.3	1.8	11.6	36.7	2.6	2.0	13.1	41.1
Wheat middlings,	9	10.30	5.10	6.8	4.8	15.7	57.3	7.6	5.3	17.5	63.9	2.4	4.1	13.1	50.4	2.7	4.5	14.9	56.2
Rye bran,	2	10.90	3.80	3.6	2.3	15.9	63.5	4.0	2.6	17.8	71.3	-	-	-	-	-	-	-	-
Rye middlings,	1	12.50	3.50	3.3	5.9	11.6	64.2	3.7	5.6	13.2	73.5	-	-	-	-	-	-	-	-
Oat middlings,	1	6.40	4.50	18.3	3.5	11.3	56.0	19.5	3.7	12.1	59.9	-	-	-	-	-	-	-	-
Pea bran,	1	7.10	3.10	42.9	1.1	9.6	36.2	46.2	1.2	10.3	39.0	-	-	-	-	-	-	-	-
Buckwheat middlings,	1	11.50	4.80	4.6	6.6	22.6	49.9	5.2	7.5	25.5	56.4	-	-	-	-	-	-	-	-
Gluten meal,	38	9.00	.90	3.3	8.3	27.3	51.2	3.6	9.1	30.0	56.3	1.0	7.3	23.7	46.6	1.2	8.0	26.1	51.2
Gluten meal (Chicago), old process,	3	9.20	.80	1.1	6.2	30.4	52.2	1.2	6.8	33.5	52.5	-	5.8	27.1	48.4	-	6.5	29.8	53.5
Gluten meal (Chicago), new process,	4	9.60	1.30	2.4	6.0	38.4	42.3	2.6	6.6	42.5	46.8	-	-	-	-	-	-	-	-
Gluten meal (King),	2	7.20	1.70	1.4	19.1	34.6	35.9	1.5	20.6	37.4	38.7	-	18.1	31.8	30.2	-	19.6	34.4	32.5
Gluten feed (Buffalo),	15	8.10	.90	6.8	11.9	23.0	49.3	7.4	12.9	25.0	53.7	5.4	9.6	19.6	39.9	5.9	10.4	21.3	43.5
Gluten feed (Pope),	1	14.00	.70	1.5	14.0	33.2	36.6	1.8	16.3	38.7	42.4	-	-	-	-	-		-	-
Gluten feed (Peoria),	4	7.20	1.20	7.6	12.4	20.5	51.1	8.2	13.4	22.1	55.0	6.0	9.8	17.0	46.0	6.4	10.6	18.3	49.5
Maize feed (Chicago),	5	8.20	.60	7.5	7.1	24.9	51.7	8.2	7.7	27.1	56.3	6.2	6.5	21.2	45.5	6.7	7.1	23.2	49.5

A. Composition and Digestibility of Cattle Feeds — Concluded.

NAME.	Analyses.	Composition.										Digestibility.							
		Fresh or air-dry substance.						Water-free substance.				Fresh or air dry substance.				Water-free substance.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
VI. By-products and Refuse — Concluded.																			
Starch feed (Pope),	1	5.50	.80	14.5	10.7	10.7	57.8	15.2	11.3	11.3	61.3	-	-	-	-	-	-	-	-
Atlas gluten meal,	2	9.90	1.10	11.1	12.8	34.3	30.8	12.3	14.2	38.1	34.2	-	12.9	25.0	25.9	-	11.6	27.8	28.7
Glucose feed (Richardson),	1	6.30	1.00	11.0	11.0	21.6	49.1	11.7	11.7	23.1	52.4	-	-	-	-	-	-	-	-
Corn germ meal,	1	9.30	7.60	8.3	10.7	25.7	38.4	9.2	11.8	28.3	42.4	-	-	-	-	-	-	-	-
Corn germ feed,	1	7.50	.80	13.0	11.3	10.0	57.4	14.1	12.2	10.8	62.0	-	-	-	-	-	-	-	-
Corn screenings,	1	11.10	2.10	2.9	4.0	7.4	72.5	3.3	4.5	8.3	81.5	-	-	-	-	-	-	-	-
Proteina (mixed feed),	4	8.40	2.50	10.0	6.6	21.7	50.8	10.9	7.2	23.7	55.5	-	-	-	-	-	-	-	-
Excelsior feed,	1	7.10	4.10	13.7	5.0	9.1	61.0	14.7	5.4	9.8	65.7	-	-	-	-	-	-	-	-
Oat feed,	10	7.50	4.90	13.0	4.3	11.8	58.5	14.1	4.7	12.5	63.4	-	-	-	-	-	-	-	-
Rye feed,	2	8.90	2.70	3.3	2.6	13.8	68.7	3.6	2.9	15.1	75.4	-	-	-	-	-	-	-	-
Cocoa-nut meal,	1	9.30	5.20	17.1	11.7	20.5	36.2	18.8	12.9	22.6	40.0	-	-	-	-	-	-	-	-
Rice meal,	1	9.90	8.40	5.7	13.2	11.6	51.2	6.3	14.6	12.9	56.1	1.5	11.2	7.3	44.0	1.6	12.4	8.1	48.9
Louisiana rice bran,	1	10.20	9.50	13.4	8.7	8.8	49.4	14.9	9.7	9.8	55.0	-	-	-	-	-	-	-	-
Peanut feed,	2	10.00	2.60	56.4	5.5	8.9	16.6	62.7	6.1	9.9	18.4	6.8	5.0	6.3	8.1	7.5	5.4	7.0	9.0

Peanut husks,	1	13.00	1.20	66.0	1.7	5.0	13.1	75.9	1.9	5.7	15.1	-	-	-	-	-	-	-	-
Bakery refuse,	1	13.30	10.10	.3	5.5	8.0	62.8	.4	6.4	9.2	72.4	-	-	-	-	-	-	-	-
Vinegar mash,	1	94.50	.20	.5	.5	.9	3.4	8.6	8.5	16.5	63.4	-	-	-	-	-	-	-	-
Refuse from starch works,	1	57.00	.40	3.2	4.4	9.6	25.4	7.5	10.2	22.4	59.0	-	-	-	-	-	-	-	-
Oat meal and barley refuse,	1	7.80	3.50	20.6	3.5	6.9	57.7	22.3	3.8	7.5	62.6	-	-	-	-	-	-	-	-
Glucose refuse,	1	6.70	1.10	4.5	9.9	19.7	58.0	4.8	10.6	21.1	62.3	-	-	-	-	-	-	-	-
Dried brewers' grain,	4	9.90	4.10	10.2	4.4	21.0	50.4	11.3	4.9	23.3	56.0	5.4	4.0	16.6	39.7	6.0	4.5	18.4	33.0
Malt sprouts,	1	15.40	5.30	12.5	3.3	23.0	40.5	14.8	3.9	27.2	47.8	4.3	3.3	18.4	27.9	5.0	3.9	21.6	33.0
Damaged wheat,	1	13.10	2.00	2.7	2.2	14.2	65.8	3.1	2.5	16.3	75.8	-	-	-	-	-	-	-	-
Cocoa dust,	1	7.10	6.30	5.5	24.1	14.4	42.6	5.9	25.9	15.5	45.9	-	-	-	-	-	-	-	-
Broom-corn waste,	1	8.70	4.50	35.9	.9	6.1	43.9	39.3	1.0	6.8	48.0	-	-	-	-	-	-	-	-
Refuse from cows' manger (ensilage),	6	72.90	2.00	9.4	.4	2.2	12.5	34.6	1.5	8.4	45.9	-	-	-	-	-	-	-	-
Cotton hulls,	3	10.00	2.70	41.5	2.5	4.4	39.0	46.1	2.8	4.8	43.3	19.5	2.2	.3	13.3	21.7	2.2	.4	17.7
Cotton-hull bran,	1	9.60	1.00	35.5	1.1	2.4	49.5	39.3	1.2	2.6	54.7	-	-	-	-	-	-	-	-
Apple pomace,	3	82.80	.40	2.9	.8	1.2	11.9	17.1	4.5	6.8	69.5	-	-	-	-	-	-	-	-
Apple-pomace silage,	1	85.30	.60	3.3	1.1	1.2	8.5	22.2	7.4	8.2	58.0	-	-	-	-	-	-	-	-
Sugar-beet pulp, from diffusion battery,	1	89.70	.10	2.5	.1	1.4	6.2	23.7	1.0	12.4	61.9	-	-	-	-	-	-	-	-
Sugar-beet refuse,	1	28.90	5.30	5.8	.3	8.6	51.1	8.1	.4	12.1	71.9	-	-	-	-	-	-	-	-
Corn cobs,	6	7.00	1.30	31.4	.5	2.7	56.5	34.0	.6	2.9	61.1	20.4	.3	.4	33.9	22.1	.3	.4	36.7
Palmetto root,	1	11.50	3.90	18.9	.4	3.4	61.9	21.3	.5	3.8	70.0	-	-	-	-	-	-	-	-

B. Fertilizing Ingredients in Fodder Articles.

[Figures equal percentages or pounds in 100.]

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
I. Green Fodders.						
Fodder corn,	14	78.6	.41	.33	.15	$1 43
Fodder-corn ensilage,	7	80.2	.42	.39	.13	1 52
Corn and soja-bean ensilage,	1	71.0	.79	.44	.42	2 56
Millet and soja-bean ensilage,	5	75.8	.48	.5	.12	1 81
Millet ensilage,	3	73.8	.26	.62	.14	1 48
Sorghum,	7	82.2	.23	.23	.09	87
Mochi millet,	3	62.6	.61	.41	.19	2 06
Millet (*Panicum crus-galli*),	1	75.1	.46	.49	.11	1 70
Green oats,	3	83.4	.49	.38	.13	1 58
Green rye,	2	72.0	.30	.64	.12	1 48
Vetch and oats,	1	86.1	.24	.79	.09	1 93
Horse bean,	1	74.7	.68	.35	.08	2 06
Soja bean,	1	73.2	.29	.53	.15	1 37
Soja bean (early white),	1	66.6	.94	.91	.21	3 37
Soja bean (early green),	1	69.8	.84	.71	.20	2 92
Soja bean (medium black),	1	76.9	.80	.57	.18	2 74
Soja bean (late),	1	79.7	.60	.68	.14	2 26
Kidney vetch,	1	80.9	.56	.35	.09	1 78
Cow-pea vines,	1	78.8	.27	.31	.10	1 06
Prickly comfrey,	1	86.8	.37	.76	.12	1 77
Serradella,	2	82.6	.41	.42	.14	1 54
Common buckwheat,	1	84.7	.44	.54	.09	1 69
Flat pea (*Lathyrus sylvestris*),	1	78.6	1.05	.45	.14	3 14
Hungarian grass,	1	74.3	.39	.54	.16	1 54
White lupine,	1	85.4	.44	.25	.05	1 36
Yellow lupine,	1	85.1	.40	.44	.09	1 49
Spanish moss,	1	60.8	.28	.26	.03	96
II. Hay and Dry Coarse Fodders.						
English hay,	12	11.9	1.32	1.55	.30	5 02
Rowen,	13	18.5	1.63	1.50	.44	5 85
Timothy hay,	3	11.3	1.24	1.46	.34	4 78
Red top (*Agrostis vulgaris* With.),	4	7.7	1.15	1.02	.36	4 14

* The valuation is based on the following prices per pound of essential fertilizing ingredients: nitrogen, 12 cents; potassium oxide, 5 cents; phosphoric acid, 5 cents.

B. Fertilizing Ingredients in Fodder Articles — Continued.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
II. Hay and Dry Coarse Fodders — Con.						
Kentucky blue-grass (*Poa pratensis* L.),	2	5.3	1.32	1.69	.43	$5 29
Orchard grass,	4	8.8	1.31	1.89	.41	5 44
Meadow fescue,	6	8.9	.99	2.10	.40	4 87
Perennial rye-grass,	2	9.1	1.23	1.55	.56	5 06
Italian rye-grass,	4	8.7	1.19	1.27	.56	4 69
Salt hay,	1	5.4	1.18	.72	.25	3 80
Japanese millet (white head),	3	10.5	1.11	1.22	.40	4 28
Common buckwheat,	1	8.5	2.62	3.21	.53	10 02
Silver-hull buckwheat,	1	8.9	1.78	2.38	.86	7 51
Japanese buckwheat,	1	5.7	1.63	3.32	.85	8 08
Fodder corn,	7	7.9	1.76	.89	.54	5 65
Corn stover,	17	9.3	1.04	1.38	.29	4 17
Teosinte,	1	6.1	1.46	3.70	.55	7 75
Summer rape,	1	11.1	2.05	4.67	.57	10 16
Millet hay,	1	9.8	1.28	1.69	.49	5 25
Mammoth red clover,	3	11.4	2.23	1.22	.55	7 12
Medium red clover,	2	7.9	2.18	2.29	.45	7 97
Alsike clover,	6	9.9	2.34	2.23	.67	8 52
Lucerne (alfalfa),	4	6.3	2.08	1.46	.53	6 98
Bokhara clover,	2	7.4	1.98	1.83	.56	7 14
Blue melilot,	1	8.2	1.92	2.80	.54	7 95
Sainfoin,	1	12.2	2.63	2.02	.76	9 09
Sulla,	2	9.4	2.46	2.09	.45	8 36
Lotus villosus,	2	11.5	2.10	1.81	.59	7 44
Soja bean,	2	6.3	2.32	1.08	.67	7 32
Cow pea,	1	9.0	1.64	.91	.53	5 38
Small pea,	1	5.8	2.50	1.99	.59	8 58
Flat pea (*Lathyrus sylvestris*),	1	8.9	3.51	2.34	.82	11 58
Serradella,	2	7.4	2.70	.65	.78	7 91
Scotch tares,	1	15.8	2.96	3.00	.82	10 92
Spring vetch,	1	8.2	2.20	2.76	.74	8 78
Vetch and oats,	3	9.9	1.30	1.35	.56	5 03
Soja-bean straw,	1	13.0	.71	1.06	.26	3 02
Millet straw,	1	13.5	.69	1.76	.18	3 58

* See note on page 94.

B. Fertilizing Ingredients in Fodder Articles — Continued.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
II. Hay and Dry Course Fodders — Con.						
White daisy,	1	9.7	.28	1.25	.44	$2 36
Dry carrot tops,	1	9.8	3.13	4.88	.61	13 00
Barley straw,	2	10.0	1.13	2.41	.22	5 34
III. Roots, Bulbs, Tubers, etc.						
Beets, red,	8	87.8	.23	.44	.09	1 08
Beets, sugar,	4	87.0	.22	.48	.10	1 12
Beets, yellow fodder,	1	90.6	.19	.46	.09	1 01
Mangolds,	3	87.6	.15	.34	.14	84
Ruta-bagas,	3	89.1	.19	.49	.12	1 07
Turnips,	4	89.7	.17	.38	.12	81
Carrots,	3	89.0	.16	.46	.09	93
Parsnips,	1	80.3	.22	.62	.19	1 34
Potatoes,	4	80.1	.29	.51	.08	1 29
Artichokes,	1	77.5	.46	.48	.17	1 74
Japanese radish (*merinia*),	1	93.3	.08	.28	.05	52
Japanese radish (*niyas hige*),	1	92.6	.08	.34	.05	58
IV. Grains, Seeds, Fruits, etc.						
Corn kernels,	13	10.9	1.82	.40	.70	5 46
Corn and cob meal,	29	9.0	1.41	.47	.57	4 42
Oat kernels,	1	9.0	2.10	–	–	–
Soja beans,	2	18.3	5.30	1.99	1.87	16 58
Red adzinki beans,	1	14.8	3.24	1.54	.94	10 26
White adzinki beans,	1	16.9	3.33	1.48	.97	10 44
Saddle beans,	1	12.3	2.12	2.13	1.52	8 74
Japanese millet,	1	13.7	1.73	.38	.69	5 22
Common millet,	1	12.7	2.04	.36	.85	6 11
Chestnuts,	1	44.9	1.18	.63	.39	3 85
Cranberries,	1	89.4	.08	.10	.03	32
Apples,	2	79.9	.13	.19	.01	66
V. Flour and Meal.						
Corn meal,	3	14.1	1.92	.34	.71	5 66
Hominy feed,	1	8.9	1.63	.49	.98	5 38
Ground barley,	1	13.4	1.55	.34	.66	4 72
Wheat flour,	2	12.1	2.02	.36	.35	5 56

* See note on page 94.

B. Fertilizing Ingredients in Fodder Articles — Concluded.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
V. Flour and Meal — Con.						
Pea meal,	1	8.9	3.08	.99	.82	$9 20
Soja-bean meal,	1	10.8	5.89	2.23	1.57	17 94
Peanut meal,	1	8.0	7.84	1.54	1.27	21 63
VI. By-products and Refuse.						
Linseed meal (old process),	4	8.0	5.39	1.21	1.78	15 93
Linseed meal (new process),	5	7.9	5.83	1.25	1.69	16 93
Cotton-seed meal,	24	8.2	6.70	1.83	2.47	20 38
Wheat bran,	10	9.9	2.36	1.40	2.10	9 16
Wheat middlings,	2	10.2	2.75	.75	1.25	8 60
Rye middlings,	1	12.5	1.84	.81	1.26	6 47
Rye feed,	1	9.6	1.95	.98	1.56	7 22
Gluten meal,	5	8.5	5.09	.05	.42	12 69
Gluten feed (Buffalo),	5	8.2	3.72	.06	.34	9 31
Gluten meal (Chicago),	2	9.6	5.75	.06	.43	14 29
Gluten meal (King),	1	7.8	5.69	.08	.69	14 43
Dry distillery feed (Atlas),	1	11.2	5.30	.16	.23	13 50
Dry brewers' grain,	2	8.6	2.68	.85	1.05	8 33
Proteina,	1	10.1	2.97	.57	1.00	8 70
Damaged wheat,	1	13.1	2.26	.51	.83	6 76
Louisiana rice bran,	1	10.3	1.43	.84	1.71	5 98
Glucose refuse,	1	6.7	3.37	.09	.61	8 09
Cocoa dust,	1	7.1	2.30	.63	1.34	7 49
Broom-corn waste (stalks),	1	10.4	.87	1.86	.46	4 41
Cotton hulls,	3	10.6	.75	1.08	.18	3 06
Peanut feed,	2	10.0	1.46	.79	.23	4 52
Peanut husks,	1	13.0	.80	.48	.13	2 53
Meat meal,	1	8.0	11.21	.30	.73	27 93
Apple pomace,	2	80.5	.23	.13	.02	70
Corn cobs,	8	12.1	.50	.60	.06	1 86
Palmetto roots,	1	11.5	.54	1.38	.16	2 83
Buckwheat hulls,	1	11.9	.49	.52	.07	1 77
VII. Dairy Products.						
Buttermilk,	1	91.1	.51	.05	.04	1 31
Skim-milk,	22	90.3	.59	-	-	-
Whey,	1	93.7	.10	.07	.17	48

* See note on page 94.

C. *Analyses of Dairy Products (Per Cent.).*

		Solids.			Fat.					
	Analyses.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Curd.	Salt.	Ash.
Whole milk,	1,993	18.27	10.20	13.47	7.54	1.72	4.14	-	-	-
Skim-milk,	351	10.48	7.68	9.48	1.02	.05	.32	-	-	-
Buttermilk,	31	9.86	6.83	8.33	.38	.11	.27	-	-	-
Cream (from Cooley process),	197	32.78	18.12	26.10	25.00	10.53	17.66	-	-	.62
Cream (concentrated commercial),	2	50.12	48.71	49.41	45.37	44.33	44.85	-	-	-
Butter (salted),	38	92.89	85.35	89.21	89.05	81.43	84.34	1.18	3.69	-
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	.76	-	-
Whole-milk cheese (Jersey),*	1	-	-	62.84	-	-	37.32	22.13	-	3.39
Whole milk cheese,*	1	-	-	64.17	-	-	34.34	26.69	-	3.14
Cheese from milk skimmed after twelve hours' standing,*	1	-	-	62.70	-	-	27.81	30.37	-	4.52
Cheese from milk skimmed after twenty-four hours' standing,*	1	-	-	57.76	-	-	23.42	31.99	-	2.35
Cheese from milk skimmed after thirty-six hours' standing,*	1	-	-	56.05	-	-	17.67	33.24	-	5.14
Cheese from milk skimmed after forty-eight hours' standing,*	1	-	-	54.59	-	-	15.77	34.94	-	3.88
Cheese from skim-milk, with addition of buttermilk,*	1	-	-	51.62	-	-	18.35	28.63	-	4.64
Genuine oleomargarine cheese,*	1	-	-	62.10	-	-	31.66	25.94	-	4.50

* From analyses made in 1875.

Tables of the Digestibility of American Feed Stuffs.

Experiments made in the United States.

Compiled by J. B. LINDSEY.

I. Experiments with Ruminants.

II. Experiments with Swine.

Dec. 31, 1895.

TABLES OF THE DIGESTIBILITY OF AMERICAN FEED STUFFS.

I. Experiments with Ruminants.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Hay and Dry Coarse Fodders.								
Timothy hay (in bloom),	3	5	55.6—65.7 60	56.4—66.8 60	55.8—62.1 58	51.5—61.8 57	50.3—60.4 56	57.5—71.8 63
Timothy hay (past bloom),	5	10	47.0—61.1 53	48.4—62.3 54	37.2—56.8 47	34.6—61.1 53	38.8—50.4 45	55.6—66.9 60
Timothy hay (average all trials),	11	25	57	58	52	60	48	63
Hay of mixed grasses (medium in protein*),	1	2	-	-	49	50	40	58
Hay of mixed grasses (rich in protein),	4	14	54—62 58	- -	56—66 60	44—57 49	56—64 59	56—63 59
Rowen (mixed grasses),	1	4	- -	63—67 65	65—68 66	44—50 46	68—70 69	63—68 65
Rowen (chiefly timothy),	1	4	- -	62—67 64	62—73 66	48—51 49	66—69 68	60—65 63
Average (both samples),	-	-	-	65	66	47	68	64
Salt hay of black grass (*Juncus Gerardi*),	1	2	57—62 60	- -	57—64 60	37—46 41	62—63 63	53—59 56
High-grown salt hay (largely *Spartina juncea*),	1	2	51—55 53	- -	46—55 50	42—51 47	62—63 63	52—55 53
Branch grass (*Spartina juncea*, with *Spartina stricta*, var. *glabra*),	1	2	55—57 56	- -	48—56 52	27—36 31	61—63 62	54—55 54
Low meadow fox grass (*Spartina juncea*),	1	2	52—54 53	- -	49—53 51	17—30 24	- 57	51—52 52

Meadow, swale or swamp hay,	1	2	38—40 39	- -	30—36 33	- 44	31—37 34	- 46
Hay of vetch and oats,	1	2	58—58 58	- -	65—67 66	17—20 19	60—61 60	54—54 54
Clover and timothy hay (poorly cured),	1	2	54.3—55.3 55	- -	52—54.4 53	- 58	37.5—37.9 38	- 60
Hungarian hay,	1	2	64.3—65.8 65	65.9—66.8 66	66.8—68.5 68	- 64	- 60	66.9—67.4 67
Hay of blue-joint grass (past bloom) (*Calamagrostis Canadensis*),	1	1	40	42	37	37	57	43
Hay of blue-joint grass (bloom),	1	2	66.7—70.5 69	68.1—71.5 70	71.5—73.4 72	51.4—53.3 52	68.2—72.3 70	66.4—70.9 69
Hay of orchard grass (ten days after bloom),	1	1	54	56	58	54	59	54
Hay of orchard grass (stage not given),	1	2	57.5—60 59	- -	60—66.7 64	55.4—57.4 56	60—60.8 60	55.3—57.3 56
Average of both samples,	2	3	56	56	61	55	60	55
Hay of red top,	2	3	57.6—62.3 60	59.3—63.6 61	60.8—61.8 61	44.2—58.8 51	60.4—62.4 61	59.1—65.2 62
Dried pasture grass,	1	1	71	-	77	60	72	73
Oat straw,	1	2	49—51.7 50	50.8—53.2 52	57.2—58 58	35.5—41 38	- -	51.8—54.6 53
Barley hay,	1	4	59	62	62	41	65	63
Hay of Legumes.								
Soja-bean hay,	1	2	61.9—62.7 62	- -	59.5—62.1 61	18.7—39.7 29	70.1—72.1 71	66.1—71.5 69
Peanut-vine hay,	1	2	59.5—60.2 60	- -	51.2—52.6 52	62.1—69.8 66	63—63.6 63	69.3—69.7 70

* Below 10 per cent.

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Hay of Legumes — Concluded.								
Cow-pea-vine hay (fair quality),	1	2	- 59	- -	41.2—44.6 43	46.4—53.7 50	63.9—65.1 65	- 71
Clover hay (late bloom, fair quality),	1	2	54.4—55.5 55	55.9—56.4 56	43.8—49 46	51.8—54.8 53	49.3—59.1 55	63.3—64.8 64
Clover hay (good quality),	1	2	50.8—53.5 52	51.6—54.3 53	46.6—49 48	40—48 43	47—52.2 49	56.8—58.9 58
White clover hay (bloom),	1	1	66	67	61	51	73	70
Scarlet clover hay (*T. incarnatum*),	2	6	56.8—65.4 62	- -	32—58.1 41	35.1—54 44	64—70 66	52—73.6 60
Alsike clover (*T. hybridum*),	2	3	61.1—64.3 62	62—65.2 63	51—58.7 53	35.1—69.3 50	64—69.2 66	66.5—74.1 71
Alfalfa (lucerne) (late bloom),	1	2	-	-	49	54	77	64
Alfalfa (lucerne) (stage not given),	1	1	-	-	43	48	69	72
Corn Fodder (partially Air Dry).								
Corn stover (whole plant),	1	4	61.1—62 62	- -	64.8—68.3 67	48.1—55.8 52	49.6—54.8 52	62.5—64.5 64
Corn stover (tops and blades),	1	2	59—60.5 60	- -	71.1—71.7 71	70.6—71.9 71	54.2—56.6 55	61.9—62.6 62
Corn stover (leaves of),	1	2	54.8—56.2 56	- -	54.3—67 61	60.6—65.4 63	43.1—68.8 56	57.1—60.6 59

Corn stalk (below ear),	1	2	64—69 67	- -	71—75 74	79—80 80	15—27 21	65—73 69
Topped stover (part above ear),	1	2	52—58 55	- -	69—72 71	62—65 64	17—27 22	50—57 54
Corn husks,	1	2	71—73 72	- -	78—81 80	23—42 33	24—35 30	75 -
Corn leaves (below ear),	1	2	62—67 65	- -	75—80 78	52—59 56	28—41 35	66—70 68
Flint corn fodder (ears just forming),	1	3	69—72 70	71—73 71	72—73 72	63—71 67	69—73 70	71—73 71
Flint (mature) field corn fodder,	4	9	68—73 71	71—75 73	69—80 76	59—77 70	59—79 65	69—78 73
Dent (mature) field corn fodder,	5	10	63—70 68	- -	43—61 54	72—82 78	43—61 53	68—81 76
Average both kinds,	-	-	70	-	65	74	59	74
Dent (in milk) field corn fodder,	5	11	58.8—66 63	- -	50—71 64	67—79 75	44—51 50	61—69 66
Dent (immature, Burrill and Whitman, coarse),	1	4	51—64 57	- -	45—74 59	66—84 76	20—36 27	57—66 61
Dent (immature, no ears formed),	4	8	61—70 65	63—71 67	63—77 71	59—72 66	57—67 62	57—70 64
Sweet corn fodder (mature),	3	6	60—71 67	62—74 70	70—77 74	63—71 74	54—73 64	57—73 68
Miscellaneous Dry Substances.								
Hay of wild oat grass (*Danthonica spicata*),	2	3	59.6—68.3 64	61.2—69.1 65	65.1—70.6 68	38.2—62.8 50	48.6—68 58	62.1—68.8 65
Hay of witch grass (*Triticum repens*),	2	4	59.9—62.7 61	61—64.3 62	56.4—67.6 62	53.6—60 57	49.5—64.2 58	62.1—69.9 66
Hay of buttercups (*Ranunculus acris*),	1	2	56	57	41	70	56	67

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Miscellaneous Dry Substances — Concluded.								
Hay of white weed (*Leucanthemum vulgare*),	1	2	58	58	46	62	58	67
Cat's-tail millet (*Pennesetum spicatum*),	1	2	61.1—63.6 62	- -	64.7—68.4 67	44.7—47.6 46	60.6—64.6 63	58.3—60 59
Johnson-grass hay,	1	1	55	-	58	39	45	54
Sorghum fodder (leaves),	1	2	59.9—66.3 63	- -	64.9—75.9 70	46.3—47.1 47	59.5—62.2 61	62.5—66.6 65
Sorghum bagasse,	1	1	61	-	64	46	14	65
Cotton-seed hulls (fed alone),	4	13	35—47.5 41	- -	.54—57.6 47	58.2—89.3 79	.00—24.6 6	12.9—45.7 34
Cotton-seed hulls when fed with cotton-seed meal (7 to 1 and 6 to 1),	1	3	41 -	- -	33—40 38	- 78	- -	48—50 49
Cotton-seed hulls when fed with cotton-seed meal (4 to 1 to 1½ to 1),	3	11	43—48 45	- -	43—50 46	66—80 76	- -	49—57 51
Cotton-seed feed (hulls and meal, 7 to 1 and 6 to 1),	1	3	45—46 46	- -	34—40 37	81—82 82	44—46 45	50—51 50
Cotton-seed feed (hulls and meal, 4 to 1 to 1½ to 1),	3	11	52—56 55	- -	43—49 46	84—86 85	61—65 62	49—56 54
Green Fodders.								
Dent corn fodder (immature),	4	11	64—74 68	- -	60—76 67	37—83 68	56—80 66	64—79 71
Dent corn fodder (in milk),	3	9	70	-	64	78	61	76

Dent corn fodder (glazing),	5	9	67	-	51	78	54	75
Dent corn fodder (mature),	2	4	65	-	55	73	51	72
Average (glazing and mature),	7	13	66	-	52	76	53	74
Dent corn fodder (ears glazing, Burrill and Whitman, coarse),	1	2	51—54 52	- -	46—47 46	74—82 78	20—28 24	87—61 59
Sweet corn fodder (milk),	1	2	77—78 77	- -	74—76 75	73—74 74	77—78 77	80—81 81
Early amber sorghum (just after blossom),	1	2	60.9—61.7 61	- -	41.7—45.3 42	67 -	37.7—42.5 40	70.4—70.8 71
Sorghum in blossom (variety not stated),	1	2	73.1—73.3 73	- -	74—75 75	81.3—81.6 81	51.1—55.7 53	78.2—78 78
Average both samples,	2	4	67	-	59	74	46	74
Green grass (young),	1	1	69	-	74	55	65	72
Same (dry),	1	1	71	-	77	60	71	73
Pasture grass,	1	2	71.9—75.6 74	- -	74.6—76.5 76	74—74.9 74	74—76.5 75	73.8—77.1 75
Average of three samples,	-	-	71	-	76	63	70	73
Soiling barley (full bloom),	1	2	- -	62—71 66	49—64 56	61—63 62	69—71 70	69—76 73
Barley and peas (full bloom),	1	2	- -	55—65 60	55—65 60	38—49 44	73—81 77	56—67 61
Soiling rye (formation of head),	1	2	73.2—74 74	- -	78.9—80.4 80	73.6—74.8 74	78 6—79.7 79	69.7—71.4 71
Hungarian grass (probably in bloom),	1	4	61—67 63	63.4—68.8 66	65.4—71.7 68	47.8—56 52	59.4—66.4 62	63.5—68.4 66
Soiling clover (late blossom),	1	2	64.9—67.3 66	- -	52.3—52.9 53	63—66.1 65	65.8—68.3 67	76.1—79.3 78

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Green Fodders — Concluded.								
Scarlet clover (late bloom),	1	3	- -	68—70 69	54—58 56	63—69 66	- 77	74—75 74
Average two samples clover,	2	5	66	67	55	66	73	77
Corn Silage.								
Dent silage (immature),	5	13	60—68 64	- -	71—78 70	64—85 71	42—65 54	60—70 66
Dent silage (milk),	4	12	60—74 65	- -	46—80 64	78—90 87	45—63 52	63—73 69
Dent silage (average of both),	9	26	65	-	68	79	53	67
Dent silage (stage uncertain, North Carolina),	1	4	53—67 60	- -	43—64 56	55—79 70	10—34 24	61—76 68
Flint silage (ears glazing),	4	11	68—78 75	66—80 77	75—79 77	- 82	48—73 65	71—83 79
Fine crushed silage (steers),	1	2	60.4—68 64	- -	72—78 75	75—77 76	32—44 38	60—70 65
Fine crushed silage (sheep),	1	2	51.5—56 54	- -	59.5—67.7 64	67.5—69 68	21—22 21.5	52.6—57.3 55
Corn silage (raw, ears mature),	1	1	-	-	59	86	45	71
Same (cooked),	1	1	-	-	70	87	39	75
Sweet corn ensilage (occasional ears mature),	1	2	66.6—69.6 68	68.5—71.7 70	68.4—73.7 71	82.3—84.6 83	52.7—55.2 54	70.7—73 72
Soja-bean ensilage,	1	2	52.2—65.8 59	- -	47.1—62.5 55	66.4—77.3 72	71.3—80.2 76	45.9—58.2 52

Roots, Tubers, etc.								
Potatoes,	1	3	73.3—80.1 77	74.6—81.2 78	- -	13 -	43.4—45.4 44	87.3—93.4 91
Sugar beets,	1	2	94.2—94.8 95	97.6—99.9 99	88.5—113 100	46.4—53.5 50	90—92.6 91	99.8—100 100
Mangolds,	1	2	77.1—80 79	82.7—87 85	26.8—58.8 43	- -	69.7—79.8 75	90.8—91.9 91
English flat turnips,	1	2	90.7—94.9 93	93.2—99 96	89.2—117 100	82.5—92.5 98	84.5—95 90	96—97 97
Ruta-bagas,	1	2	84.4—90 87	89.2—93 91	61—87.5 74	76.8—91.6 84.2	74.7—85.9 80.3	94.4—95.1 95
Grains and Seeds.								
Corn meal (maize),	2	5	83—98 88	- -	- -	80—98 92	40—77 60	85—100 93
Corn and cob meal,	1	3	74—83 79	- -	2—86 45	82—85 84	43—65 52	86—91 88
Pea meal,	1	2	85—88 87	86—89 88	25—26 26	52—57 55	80—86 83	93—94 94
Raw cotton seed,	1	2	63—69 66	- -	65—86 76	- 87	66—70 68	49—50 50
Roasted cotton seed,	1	2	53—58 56	- -	62—69 66	68—75 72	44—50 47	50—53 51
Soja-bean meal,	1	2	75—82 79	- -	28—50 50	81—90 85	89—91 90	71—73 72
Cotton-seed meal,	2	6	67—82 76	- -	- 32	87—100 93	83—96 88	44—75 64
By-products.								
Gluten meal,	1	2	85—90 87	86—92 89	- 33	86—90 88	83—90 87	88—94 91
Chicago gluten meal,	1	2	87—89 88	- -	- -	92—94 93	87—91 89	93—94 93

Table of the Digestibility of American Feed Stuffs — Concluded.

KIND OF FODDER.	Number of Different Samples	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
By-products — Concluded.								
King gluten meal,	1	2	79—82 81	- -	- -	91—97 94	- 91	78—81 79
Average gluten meals,	3	6	85	-	-	92	89	88
Buffalo gluten feed (one lot),	1	2	76—80 78	- -	40—46 43	81—82 81	84—86 85	78—84 81
Buffalo gluten feed (another lot),	1	2	87—88 87	- -	84—94 89	92—95 93	87—87 87	87—87 87
Peoria gluten feed,	1	2	84—87 86	- -	59—97 78	76—82 79	81—85 83	90—90 90
Chicago maize feed,	1	2	83—85 84	- -	68—76 72	90—90 90	83—84 84	84—87 85
Winter-wheat bran,	1	3	57—66 62	- -	00—56 27	51—80 64	75—79 77	62—76 65
Spring-wheat bran,	1	2	62—63 63	- -	22—25 24	76—76 76	78—82 80	70—71 70
Average all wheat brans,	4	9	60	63	22	71	78	68
Wheat middlings,*	1	2	72.6—72.2 75	75.1—79.3 77	- -	84.1—86.1 85	78.4—79.4 79	80.7—84.5 83
Wheat middlings,*	1	2	79.48—85.63 83	- -	32.57—40.06 36	81.71—87.98 85	81.83—87.75 85	84.43—91.08 88
New-process linseed meal,	1	3	73—83 80	- -	49—100 74	90—98 93	86—88 85	82—87 84
Old-process linseed meal,	1	3	75—82 79	- -	38—71 57	85—92 89	86—93 89	76—79 78

Atlas meal,	1	2	80—80 80	– –	95—116 106	90—92 91	73—73 73	84—85 84
Rye meal,	1	2	85—90 87	– –	– –	63—65 64	83—85 84	89—94 92
Peanut feed,	1	2	32—32 32	– –	10—13 12	89—90 90	70—71 71	41—58 49
Malt sprouts,	1	1	67	68	34	100	80	69
Dried brewers' grains,	1	2	62—62 62	– –	50 –55 53	89—93 91	78—81 79	59—59 59
Corn cobs,	1	2	59—60 59	– –	65—66 65	44—56 50	13—22 17	60—60 60

II. Experiments with Swine.

Maize kernels (whole),	1	1	83	83	38	46	69	89
Maize meal,	2	2	89.5—89.7 90	91.3—92.1 92	29.4—48.7 39	77.6—81.7 80	86.1—89.9 88	93.9—94.2 94
Maize meal (with cobs),	1	1	76	77	29	82	76	84
Pea meal,	1	1	90	92	78	50	89	95
Barley meal,	1	1	80	80	49	57	81	87
Wheat (whole),	1	?	72	–	30	60	70	74
Wheat (cracked),	1	?	82	–	60	70	80	83
Wheat shorts,	1	2	74—79 77 *	– –	25—48 37	– –	71—75 73	85.5—88 87
Wheat bran,	1	2	53.7—68.6 61	– –	29.6—39.1 34	65.4—78.1 72	74.4—75.8 75	56—75 66

* Probably different products.

LITERATURE.

The following publications have been consulted in compiling the tables of the digestibility of American feed stuffs: —

Report of Storrs School (Connecticut) Experiment Station, 1894.

Reports of the Maine State Experiment Station for 1886, 1887, 1888, 1889, 1890, 1891, 1893, 1894.

Reports of the New York Experiment Station, 1884, 1888, 1889.

Reports of the Pennsylvania Experiment Station, 1887, 1888, 1889, 1890, 1891, 1892, 1893.

Bulletins Nos. 80 *c*, 81, 87 *d*, 97 and 118 of the North Carolina Experiment Station.

Bulletin No. 16, Utah Experiment Station.

Bulletin No. 3 of the Wisconsin Experiment Station for 1884, and Sixth Annual Report, 1889.

Bulletin No. 8 of the Colorado Experiment Station.

Bulletins Nos. 26 and 36 of the Minnesota Experiment Station.

Bulletin No. 6 of the Oregon Experiment Station.

Bulletins Nos. 13, 15 and 19 of the Texas Experiment Station.

Bulletin No. 20 of the Maryland Experiment Station.

Eleventh and Twelfth Annual Reports (1893 and 1894) of the Massachusetts State Experiment Station.

Report of Hatch Experiment Station, 1895.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Part I. On Field Experiments.

1. Experiments to study the effect of raising leguminous crops in rotation with grain crops on the nitrogen sources of the soil.
2. Observations with mixed forage crops as fodder supply.
3. Experiments to study the economy of using natural phosphates in place of acid phosphates (superphosphates).
4. Experiments to ascertain the influence of different mixtures of chemical fertilizers on the character and yield of garden crops.
5. Experiments to study the effect of phosphatic slag and nitrate of soda as compared with ground bones on field crops.
6. Experiments to study the effect of rotation of manures on permanent grass lands.

Part II. On the Work in the Chemical Laboratory.

1. Report on inspection of commercial fertilizers.
2. Report on general work in the laboratory.
3. Compilation of analyses of manurial substances.
4. Compilation of analyses of fruits, garden crops and insecticides.

PART I.

REPORT ON FIELD EXPERIMENTS.

CHARLES A. GOESSMANN.

1. FIELD EXPERIMENTS CARRIED ON FOR THE PURPOSE OF STUDYING THE EFFECT OF A LIBERAL INTRODUCTION OF CLOVER-LIKE PLANTS — LEGUMINOUS CROPS — INTO FARM PRACTICE, AS A MEANS OF INCREASING THE RESOURCES OF AVAILABLE NITROGEN PLANT FOOD IN THE SOIL UNDER CULTIVATION. (*Field A.*)

The observation of the fact that the different varieties of clover and of clover-like plants in general, as peas, beans, vetches, lupines, etc., are in an exceptional degree qualified, under favorable conditions, to convert, by the aid of certain micro-organisms of the soil, the elementary nitrogen of the air into plant food, imparts to that class of farm crops a special interest from an economical standpoint. This circumstance is in a controlling degree due to the two following causes: —

First. — The nitrogen-containing soil constituents of plant food are as a rule in a high degree liable to suffer serious changes in regard to their character and fitness as well as in reference to their quantity.

Second. — Available nitrogen-furnishing manurial substances are the most costly articles of plant food in our markets.

Field experiments which propose to show by their results to what extent the cultivation of clover-like plants can be relied on as a practical and economical means for securing efficiently nitrogen plant food for the crops to be raised have

deservedly of late engaged the most careful attention of agricultural investigators.

The experiments in part described within a few subsequent pages were planned in 1883, and have been continued to the present time upon the same field, with such modification as circumstances advised.

The investigations have been divided into three periods: —

(*a*) Study of the existing soil resources of plant food, 1884 to 1889.

(*b*) Study of the effect of excluding nitrogen plant food from outside sources and of adding nitrogen plant food in various available forms, 1889 to 1892.

(*c*) Studying the effect of the cultivation of leguminous crops on the resources of available nitrogen plant food in the soil under treatment, 1892 to 1896.

The systematic treatment of the field here under consideration, as far as suitable modes of cultivation and of manuring are concerned, was introduced during the season of 1883 to 1884.

The subdivision of the entire area into eleven plats, "one-tenth of an acre each," of a uniform size and shape, 132 feet long and 33 feet wide, with an unoccupied and unmanured space of 5 feet in width between adjoining plats, has been retained unaltered since 1884. A detailed statement of the temporary aim and general management of the experiments, as well as of the results obtained in that connection from year to year, forms a prominent part of my contemporary printed annual reports, to which I have to refer for further details, 1884–95. The first four years of the stated period 1884–89 were principally devoted to an investigation into the general character and condition of the soil under cultivation, as far as its natural and inherent resources of available phosphoric acid, nitrogen and potash were concerned. *The soil proved to be in particular deficient in potash.* Different varieties of corn (maize) were raised in succession to assist in the investigation.

Since 1889 the main object of observation upon the same field has been to study the influence of an entire exclusion of any additional nitrogen-containing manurial substance

from the soil under cultivation, as well as of a definite additional supply of nitrogen in different forms of combination on the character and yield of the crop selected for the trial.

Several plats (4, 7, 9) which for five preceding years (1883 to 1889) had not received any nitrogen compound for manurial purposes were retained in that state, to study the effect of an entire exclusion of nitrogen-containing manurial substances on the crop under cultivation ; while the remaining ones received, as before, a definite amount of nitrogen in the same form in which they had received it in preceding years, namely, either as sodium nitrate (1, 2), as ammonium sulphate (5, 6, 8), as organic nitrogenous matter in form of dried blood (3, 10) or of barn-yard manure (0). A corresponding amount of available nitrogen was applied in all these cases.

PLATS.	Annual Supply of Manurial Substances.
Plat 0,	800 lbs. of barn-yard manure, 32 lbs. of potash-magnesia sulphate and 18 lbs. of dissolved bone-black.
Plat 1, .	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 2, .	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8 5 lbs. available phosphoric acid).
Plat 3, .	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 4, .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 5, .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 6, .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 7, .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 8, .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 9, .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 10, .	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

Amount of Fertilizing Ingredients used Annually per Acre.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds
	Phosphoric acid,	80 pounds.
	Potassium oxide,	125 pounds.
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	80 pounds.
	Potassium oxide,	125 pounds.

The mechanical preparation of the soil, the incorporation of the manurial substances, the seeding, cultivating and harvesting, were carried on year after year in a like manner, and as far as practicable on the same day in case of every plat during the same year.

Kind of Crops raised.

Corn (maize),	in 1889.
Oats,	in 1890.
Rye,	in 1891.
Soja bean,	in 1892.

The annual yield of the various crops upon the different plats showed that as a rule those plats (4, 7, 9) which had not received in any form nitrogen for manurial purposes yielded much smaller crops than those that annually received in some form or other an addition of a corresponding amount of available nitrogen.

The results of four years of careful observation were expressed in the following conclusion: —

The experiments carried on upon Field A during the years 1889, '90, '91 and '92 show conclusively the importance of a liberal supply to the soil of an available form of nitrogen to secure a successful and remunerative cultivation of farm crops under otherwise corresponding favorable conditions. For even a leguminous crop, the soja bean, when for the first time raised upon Field A, did not furnish an exception to our observation (1892). (For details, see report for 1892.)

Subsequent to the year 1892, when for the first time in the more recent history of the field under discussion a leguminous crop, a late-maturing variety of soja bean, had been

raised upon it, our attention had been directed chiefly to the question, To what extent does the cultivation of soja bean, a clover-like plant, benefit the resources of available nitrogen plant food of the soil after the removal of the crop at the close of the season (for ensilage)?

It seemed of interest in our case to ascertain whether the raising of the soja bean upon Field A had increased the amount of available nitrogen stored up in the soil to such an extent as to affect the yield of succeeding crops upon those plats (4, 7, 9) which, as a rule, did not receive at any time for eight successive years an addition of available nitrogen from any other manurial source but the atmospheric air and the roots left in the soil after harvesting the crops raised.

A grain crop (oats) was selected as the crop suitable to serve for that purpose. The general management of the experiment, as far as the preparation of the soil, manuring and seeding-down are concerned, was the same as in preceding years (see tenth annual report).

An examination of the yield of the crop in 1893, secured upon the different plats, showed that the total crop per acre on those plats to which no nitrogen was applied (4, 7, 9) averaged 800 pounds less than in case of the plats which received their regular supply of nitrogen in some form or other.

Ratio of Grain to Straw (1893).

Plat 0,	1:3	Plat 6,	1:4.9
Plat 1,	1:4.1	Plat 7,	1:3.6
Plat 2,	1:3.1	Plat 8,	1:3.4
Plat 3,	1:3.2	Plat 9,	1:3.4
Plat 4,	1:2.7	Plat 10,	1:3.9
Plat 5,	1:7		

The best results in relation of total yield to yield of grain were obtained in case of those plats receiving organic nitrogen (dried blood and barn-yard manure) or nitrogen in the form of nitrate of soda; while in the case of sulphate of ammonia the ratio of grain to straw was too wide to be satisfactory.

The total yield of crops on the plats receiving no nitro-

gen addition, as compared with those receiving a nitrogen supply, was during succeeding years as follows: —

With corn in 1889, one-fifth less.

With oats in 1890, one-fifth to one-sixth less.

With rye in 1891, one-fifth to one-sixth less.

With soja bean in 1892, one-third to one-fourth less.

With oats in 1893, one-seventh to one-eighth less.

From these results it appeared that the introduction of a leguminous crop into our rotation had somewhat reduced the difference in yield between the plats receiving no nitrogen and those receiving it, yet had not entirely obliterated it. It was decided to continue the observation by repeating the raising of soja beans in 1894 and oats in 1895.

1894. — To secure, if possible, more decisive results regarding the presence and absence of available nitrogen, it was decided to use twice the amount of phosphoric acid and potassium oxide, as compared with preceding years.

Amount of Fertilizing Ingredients applied per Acre during 1894.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.

An early-maturing variety of soja bean was selected for the experiments. The fertilizer mixtures were applied as in previous years, broadcast, in the middle of April.

After proper preparation of the soil the soja beans were planted on May 12 in drills two and one-half feet apart, 6 pounds of seed being used per plat, or 60 pounds per acre. The plants appeared above ground May 21; June 5 the field was cultivated and hoed, and also on the 16th, 25th and July 12.

The plants began to bloom July 25. Owing to the protracted drought of July and August, the crop did not get that fulness of growth which might have been obtained under more favorable conditions. The crop was cut August 28.

Yield of Soja Bean when cut on Different Plats (1894).

[Pounds.]

PLATS.	Per Plat.
Plat 0,	600
Plat 1,	625
Plat 2,	700
Plat 3,	525
Plat 4,	405
Plat 5,	645
Plat 6,	615
Plat 7,	480
Plat 8,	680
Plat 9,	470
Plat 10,	570

	Per Cent.
Dry matter,	34
Moisture,	66

Conclusions.

1. A comparison of the above-stated yield of the different plats shows that those plats (4, 7, 9) which received no nitrogen addition from an outside source yielded on an average 452 pounds each, while those plats which received an addition of available nitrogen plant food, 45 pounds of nitrogen per acre, yielded on an average 620 pounds each, — a difference of one-third in favor of the latter.

2. An increase to twice the amount of phosphoric acid and potassium oxide, as compared with earlier years (see report for 1892), had not changed the relative yield of the crop, as noticed in case of the late soja bean in 1892,

1895. — Oats were again selected to succeed the soja bean of the preceding season, for the purpose of admitting a direct comparison of the results of 1894 and 1895 with those obtained under corresponding circumstances during the years 1892 and 1893, when the same crops followed each other in the same order.

The field was ploughed April 29; the fertilizers were applied April 30, in the same manner and in the same quantity to each plat as in the preceding year (1894), specified upon a previous page, namely, per acre: —

Plats 4, 7, 9,	Nitrogen,	None.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.
Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.

The oats were sown in drills two feet apart, at the rate of 7 pounds per plat, or 70 pounds per acre, on May 7. The young plants showed above ground on all plats alike May 11.

To secure clean culture the cultivator was used twice, May 29 and June 12. The crop did not mature at the same time upon all plats, and was for that reason cut at different dates. It was cut when matured, on August 2 upon plats 0, 1, 2, 3, 4, 7, 9, 10, on August 8 upon plats 5 and 8 and on August 17 upon Plat 6. From this data it will be noticed that in all cases where sulphate of ammonia was used as the nitrogen supply for the raising of oats the maturing of the crop was from one to two weeks later than on all other plats, where either nitrate of soda or organic nitrogen compounds, as blood, barn-yard manure or no nitrogen-containing manurial matter, was applied. Similar results have been noticed in previous years, when summer grain crops have been raised in connection with the experiment under discussion.

Yield of Field A, Oats (1895).

[Pounds.]

PLATS.	Oats.	Straw.	Total Weight.
Plat 0,	134	254	388
Plat 1,	160	330	490
Plat 2,	150	330	480
Plat 3,	149	331	480
Plat 4,	110	233	343
Plat 5,	190	360	550
Plat 6,	155	405	560
Plat 7,	136	292	428
Plat 8,	92	458	550
Plat 9,	123	217	340
Plat 10,	169	381	550

	Per Cent.
Moisture, oats,	14.60
Moisture, straw,	15.90

Summary of Yield of Oats (1893, 1895).

[Pounds.]

PLATS.	1893.			1895.		
	Weight of Grain.	Weight of Straw and Chaff.	Total Weight.	Weight of Grain.	Weight of Straw and Chaff.	Total Weight.
Plat 0,	131	399	530	134	254	388
Plat 1,	135	555	690	160	330	490
Plat 2,	146	454	600	150	330	480
Plat 3,	166	534	700	149	331	480
Plat 4,	160	430	590	110	233	343
Plat 5,	79	551	630	190	360	550
Plat 6,	102	498	600	155	405	560
Plat 7,	119	431	550	136	292	428
Plat 8,	95	325	420	92	458	550
Plat 9,	110	370	480	123	217	340
Plat 10,	125	485	610	169	381	550

Ratio of Grain to Straw (1893, 1895).

PLATS.	1893.	1895.
Plat 0, ...	1:3	1:1.9
Plat 1, ...	1:4.1	1:2.06
Plat 2, ...	1:3.1	1:2.2
Plat 3, ...	1:3.2	1:2.2
Plat 4, ...	1:2.7	1:2.1
Plat 5, ...	1:7	1:1.9
Plat 6, ...	1:4.9	1:2.6
Plat 7, ...	1:3.6	1:2.14
Plat 8, ...	1:3.4	1:4.97
Plat 9, ...	1:3.4	1:1.76
Plat 10, ...	1:3.9	1:2.25

Average Yield of Oats on Plats receiving no Nitrogen and on Plats receiving Nitrogen (1893, 1895).

[Pounds.]

PLATS.	1893.	1895.
Plats 4, 7 and 9 (no nitrogen), ...	540.0	370.3
Plats 0, 1, 2, 3, 5, 6, 8 and 10 (receiving nitrogen),	597.5	506.0

Conclusions.

The conditions of the different plats are apparently materially the same to-day as they were two years ago. The raising of soja beans has not changed the results for the better. It remains to be seen whether the ploughing under of a leguminous crop, serving as green manure, will affect the results.

2. Observations with the Cultivation of Mixed Forage Crops. (*Field B.*)

The importance of a more liberal supply of nutritious forage crops for an economical support of dairy stock is quite generally recognized by all parties interested. To assist in the solution of that question induced the writer to devote for a series of years special attention to the raising of fodder crops of a high nutritive character and of a liberal yield. Mixed forage crops, consisting of early maturing annual leguminous crops, clover-like plants and of either oats or barley, suggested themselves for a trial; for they attain a high feeding value at a comparatively early period of the season, — towards the end of June when in bloom; they can serve with benefit in form of green fodder, hay or ensilage, as circumstances advise, and they yield under fair conditions large quantities. Experiments with peas, Scotch tares and vetches have been already described in previous reports. The results obtained induced the writer to prefer summer vetch (*vicia sativa*) to both peas and tares, in case of mixed crops. The fields used for the observation were located in different parts of the farm; they were as a rule in a fair state of cultivation, as far as the mechanical condition of the soil as well as its store of plant food was concerned. The soil consisted in the majority of cases of a somewhat gravelly loam.

Vetch and Oats.

1893. — Half an acre of a field which had served during the preceding year for the production of root crops, carrots and sugar beets was fertilized April 26 with 300 pounds of fine-ground bone and 100 pounds of muriate of potash. The fertilizer was applied broadcast and subsequently ploughed in May 8; the field was sown with oats and summer vetch, using 2 bushels of oats and 25 pounds of vetch. The seeds were sown each by itself, on account of the great difference in size and general character. The crop made an even and rapid growth. The oats headed out at the time when the vetch began to bloom. At this stage of growth the feeding as green fodder began, July 6. It was continued until the oats

turned yellowish, July 18. The remainder of the crop was then cut for hay. The total yield of the crop, counted as green fodder, with 20 per cent. of dry vegetable matter, amounted to 21,000 pounds per acre. Buckwheat was subsequently raised upon the same field as fall crop.

1894. — The field in this case was 700 feet long and 75 feet wide, equal to one and one-fifth acres (corn was raised upon it in 1893). It was ploughed Oct. 25, 1893, and manured with barn-yard manure at the rate of ten tons per acre; and was ploughed again April 18, 1894, and harrowed and subsequently seeded with oats and vetch, as described in the preceding experiment, using 4 bushels of oats and 45 pounds of vetch per acre. The seeds were, however, sown at two different times, to extend the period of the fitness of the crop for green fodder. The seed sown on the northern portion April 20 came up April 28. The southern portion of the field was seeded May 11, the plants appearing above ground May 19. The crop made a very satisfactory growth, and on June 23 the feeding of the green material from the northern portion began (the vetch being in bloom and the oats heading out), continuing until July 2, when the remainder was cut for hay. July 6 the cutting from the southern portion began, continuing until the 18th, when that remaining was cut for hay. Following is given a statement of the yield from the field: —

	Pounds.
Green material fed (19.12 per cent of dry matter), .	6,875
Hay of vetch and oats (73.66 per cent. of dry matter),	4,980

July 21 the field was ploughed and prepared for raising upon it, as a fall crop, Hungarian grass.

During the same year (1894) other observations of a similar character as previously described were carried on in other parts of the farm.

It was decided to compare the effect of muriate of potash and sulphate of potash on mixed crops, consisting of oats and vetch and of barley and vetch. The field used for this observation consisted of a light loam. It had been used during the preceding season for the cultivation of different varieties of potatoes, and had received as manure on that occasion, per acre, in one case, 400 pounds of high-grade

sulphate of potash (95 per cent.), with 600 pounds of fine-ground bone; in the other, 400 pounds of muriate of potash (80–82 per cent.), with 600 pounds of fine-ground bone. The same amount and kind of manure were applied for raising vetch and oats and vetch and barley. The field occupied by these crops was ploughed, manured, harrowed and seeded down, as far as practicable, at the same time. The seed was sown in all cases April 26. Four bushels of oats with 45 pounds of vetch were sown, as on previous occasions, while 3 bushels of barley were used, with 45 pounds of vetch, in case of barley and vetch. Both crops came up May 4, and were of a uniformly healthy condition during their subsequent growth. The barley began to head out June 20; the vetch was at that time beginning to bloom. The crop was cut for hay June 23.

Yield of Barley and Vetch per Acre.

In case of muriate of potash and bone, . .	5,737 pounds of hay.
In case of sulphate of potash and bone, . .	5,077 pounds of hay.

The oats headed out June 25; the vetch was fairly in bloom. The crop was cut for hay July 2.

Yield of Oats and Vetch per Acre.

In case of muriate of potash and bone, . .	8,051 pounds of hay.
In case of sulphate of potash and bone, . .	7,088 pounds of hay.

1895. — During that year the observations of the preceding year were repeated and in some directions enlarged upon. Aside from mixed forage crops of vetch and oats and vetch and barley, there were raised crops consisting of oats, vetch and horse bean and of oats and lentils. The field used for these experiments had been used during the preceding season either for the cultivation of potatoes or of vetch and oats. In both cases it had been manured, per acre, with either 400 pounds of muriate of potash and 600 pounds of fine-ground bone, or with 400 pounds of sulphate of potash and 600 pounds of fine-ground bone. The same kind and the same quantity of manure were applied in 1895. The field was ploughed April 25; the manure harrowed in

May 3; the seed was sown broadcast May 9. All parts of the field were treated alike, and as far as practicable on the same day. The plats occupied by the crops were in all cases 33 feet wide, with 4 feet unoccupied space between them, and from 191 to 241 feet long. The yield of areas 175 feet long and 33 feet wide, running along by the side of each other, served as our basis for comparing results (5,775 square feet).

The seed was sown May 9, at the rate of 4 bushels of oats and 45 pounds of vetch per acre. The oats came up May 16, and the vetch May 21; the former headed out July 6, and the vetch began blooming at that time. The crop was cut for hay July 16.

Yield of Vetch and Oats per Acre.

In case of muriate of potash and bone, ...	7,238 pounds.
In case of sulphate of potash and bone, ...	6,635 pounds.

Vetch, Horse Bean and Oats.

The seed was sown May 9, at the rate of 40 pounds of vetch, 120 pounds of horse bean (medium sized) and 3 bushels of oats. The oats came up May 16, the vetch on May 21 and the horse bean May 23. The crop appeared healthy and vigorous at every stage of growth. It was cut for hay July 22, when the oats were fairly headed and the remainder in bloom.

Yield of Vetch, Horse Bean and Oats per Acre.

In case of muriate of potash and bone, ...	7,398 pounds.
In case of sulphate of potash and bone, ...	5,881 pounds.

Lentils and Oats.

The seed was sown May 9, at the rate of 60 pounds of lentils and 4 bushels of oats per acre. The oats came up May 16, and the lentils on May 21; the former headed out July 6, when the latter were fairly in bloom. The crop was cut for hay July 16. The experiment was confined to a trial with sulphate of potash and bone as manure on account of want of a suitable field.

Yield of lentils and oats per acre, . . .	5,881 pounds of hay.

Composition of Mixed Forage Crops raised, 1893 to 1896.

Green crop when cut contains: —

Moisture,	76 to 80 per cent.
Dry matter,	20 to 24 per cent.

Analyses of Vetch and Barley (Equal Number of Plants of Each).

[Per Cent.]

	Muriate of Potash.	Sulphate of Potash.
Moisture at 100° C.,	78.23	77.70
Dry matter,	21.77	22.30
	100.00	100.00
Analysis of Dry Matter.		
Crude ash,	4.64	7.80
" fibre,	32.25	32.58
" fat,	2.12	2.56
" protein,	14.44	13.36
Nitrogen-free extract matter,	46.55	43.70
	100.00	100.00

Analyses of Vetch and Oats (Equal Number of Plants of Each).

[Per Cent.]

	Muriate of Potash.	Sulphate of Potash.
Moisture at 100° C.,	76.24	75.29
Dry matter,	23.76	24.71
	100.00	100.00
Analysis of Dry Matter.		
Crude ash,	9.59	8.69
" fibre,	29.83	31.28
" fat,	3.13	2.63
" protein,	18.88	15.16
Nitrogen-free extract matter,	38.57	42.24
	100.00	100.00

Analysis of Vetch, Oats and Horse Bean (Muriate of Potash).

[Three plants each of vetch and of oats and one of horse bean.]

	Per Cent
Moisture at 100° C.,	82.13
Dry matter,	17.87
	100.00

Analysis of Dry Matter.

Crude ash,	10.36
" cellulose,	30.07
" fat,	2.70
" protein,	18.93
Nitrogen-free extract matter,	37.94
	100.00

Analysis of Lentils and Oats.

	Per Cent.
Moisture at 100° C.,	78.50
Dry matter,	21.50
	100.00

Analysis of Dry Matter.

Crude ash,	5.40
" cellulose,	34.90
" fat,	2.40
" protein,	14.90
Nitrogen-free extract matter,	42.40
	100.00

Conclusions.

From the above analyses it appears that vetch and oats lead vetch and barley, on account of the larger and more foliaceous character of the oats as compared with the barley. Vetch, oats and horse bean lead in nitrogenous matter, and no doubt will exceed in regard to the nutritious character of the crop as soon as the amount of horse bean has been doubled, as indicated above. Every one of these crops compares well with clover hay, as far as its nutritive value is concerned. The large yield of these crops per acre, their high nutritive value and special adaptation for green fodder, hay or ensilage, merit serious attention for the support of farm and dairy stock. The early date of maturity presents exceptionally good chances of raising a second crop for fall supply of fodder, or for a timely preparation of the soil for winter crops. Feeding experiments carried on for several years at the station with these crops have fully established their high nutritive character for dairy stock, as well as other farm live stock ordinarily depending on the product of the meadow and pasture.

3. Field Experiments with Different Commercial Phosphates, to study the Economy of using the Cheaper Natural Phosphates or the More Costly Acidulated Phosphates. (*Field F.*)

The field selected for this purpose is 300 feet long and 137 feet wide, running on a level from east to west. Previous to 1887 it was used as a meadow, which was well worn out at that time, yielding but a scanty crop of English hay. During the autumn of 1887 the sod was turned under and left in that state over winter. It was decided to prepare the field for special experiments with phosphoric acid by a systematic exhaustion of its inherent resources of plant food. For this reason no manurial matter of any description was applied during the years 1887, 1888 and 1889.

The soil, a fair, sandy loam, was carefully prepared every year by ploughing during the fall and in the spring, to improve its mechanical condition to the full extent of existing circumstances. During the same period a crop was raised every year. These crops were selected, as far as practicable, with a view to exhaust the supply of phosphoric acid in particular. Corn, Hungarian grass and leguminous crops (cow-pea, vetch and serradella) followed each other in the order stated.

1890. — The field was subdivided into five plats, running from east to west, each 21 feet wide, with a space of 8 feet between adjoining plats. The manurial material applied to each of these five plats contained, in every instance, the same form and the same quantity of potassium oxide and of nitrogen, while the phosphoric acid was furnished in each case in the form of a different commercial phosphoric-acid-containing article, namely, phosphatic slag, Mona guano, Florida phosphate, South Carolina phosphate (floats) and dissolved bone-black. The market cost of each of these articles controlled the quantity applied, for each plat received the same money value in its particular kind of phosphate. The phosphatic slag, Mona guano, South Carolina phosphate and Florida phosphate were applied at the rate of 850 pounds per acre, dissolved bone-black at the rate of 500 pounds per acre. Nitrate of soda was applied at the rate of 250 pounds

per acre and potash-magnesia sulphate at the rate of 390 pounds per acre.

Cost per Ton.

Phosphatic slag,	$15 00
Mona guano (West Indies),	15 00
Florida rock phosphate,	15 00
South Carolina phosphate (floats),	15 00
Dissolved bone-black,	25 00

Analyses of Phosphates used.

[I., phosphatic slag; II., Mona guano; III., Florida phosphate; IV., South Carolina phosphate; V., dissolved bone-black.]

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture,	0.47	12.52	2.53	0.39	15.96
Ash,	–	75.99	89.52	–	61.46
Calcium oxide,	46.47	37.49	17.89	46.76	–
Magnesium oxide,	5.05	–	–	–	–
Ferric and aluminic oxides,	14.35	–	14.25	5.78	–
Total phosphoric acid,	19.04	21.88	21.72	27.57	15.82
Soluble phosphoric acid,	–	–	–	–	12.65
Reverted phosphoric acid,	–	7.55	–	4.27	2.52
Insoluble phosphoric acid,	–	14.33	–	23.30	0.65
Insoluble matter,	4.39	2.45	30.50	9.04	6.26

The following fertilizer mixtures have been applied annually, from 1890 to 1894, to all the plats, with the exception of Plat 3, which received in 1890 ground apatite and in 1891 no phosphate whatever, on account of the failure of securing in time apatite suitable for the trial.

Plats.	Annual Supply of Manurial Substances.	Pounds.
Plat 1 (south, 6,494 square feet),	Ground phosphatic slag,	127
	Nitrate of soda,	43
	Potash-magnesia sulphate,	58
Plat 2 (6,565 square feet),	Ground Mona guano,	128
	Nitrate of soda,	43½
	Potash-magnesia sulphate,	59
Plat 3 (6,636 square feet),	Ground Florida phosphate,	129
	Nitrate of soda,	44
	Potash-magnesia sulphate,	59
Plat 4 (6,707 square feet),	South Carolina phosphate,	131
	Nitrate of soda,	44½
	Potash-magnesia sulphate,	60
Plat 5 (6,778 square feet),	Dissolved bone-black,	78
	Nitrate of soda,	45
	Potash-magnesia sulphate,	61

The field was ploughed as a rule during the month of October, and again at the close of the month of April. The fertilizer was in each case applied broadcast soon after ploughing in the spring. The seed was sown in hills or drills, as circumstances advised, and the crop kept clean from weeds by the use of the hoe or the cultivator. The following crops were raised: —

1890, potatoes (see eighth annual report).
1891, winter wheat (see ninth annual report).
1892, serradella (see tenth annual report).
1893, Dent corn, Pride of the North (see eleventh annual report).

Summary of Yield of Crops (Pounds).

PLATS.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.
Plat 1, phosphatic slag,	1,600	380	4,070	1,660
Plat 2, Mona guano,	1,415	340	3,410	1,381
Plat 3, Florida phosphate,	1,500	215	2,750	1,347
Plat 4, South Carolina floats,	1,830	380	3,110	1,469
Plat 5, dissolved bone-black,	2,120	405	2,920	1,322

Having for four years (1890–94) in succession pursued the above-stated system of manuring each plat with a different kind of phosphate, yet of corresponding money value, it was decided to continue the experiments for the purpose of studying the after-effect of the different phosphates on the crops to be raised. To gain this end the phosphates were hereafter in all cases entirely excluded from the fertilizers applied; in addition to this change, the former amount of potash and nitrogen was increased one-half in quantity, to favor the highest effect of the stored-up phosphoric acid of the soil under treatment.

The fertilizers hereafter to be used had the following composition: —

Plat 1 (6,494 square feet),	64½ pounds of nitrate of soda. 87 pounds of potash-magnesia sulphate.
Plat 2 (6,565 square feet),	65¼ pounds of nitrate of soda. 88 pounds of potash-magnesia sulphate.
Plat 3 (6,636 square feet),	66 pounds of nitrate of soda. 89 pounds of potash-magnesia sulphate.
Plat 4 (6,707 square feet),	66¾ pounds of nitrate of soda. 90 pounds of potash-magnesia sulphate.
Plat 5 (6,778 square feet),	67½ pounds of nitrate of soda. 90½ pounds of potash-magnesia sulphate.

The results of two seasons (1894 and 1895) are as follows: —

Barley.

Yield of Crop (1894).

Plats.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1, ...	490	169	221	34.49	65.51
Plat 2, ...	405	148	251	34.07	65.93
Plat 3, ...	290	78	212	26.89	73.11
Plat 4, ...	460	144	216	31.30	68.70
Plat 5, ...	390	118	272	30.26	69.74

Rye.

Yield of Crop (1895).

Plats.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1, ...	695	195	500	28.06	71.94
Plat 2, ...	631	166	465	26.31	73.69
Plat 3, ...	383	143	240	37.34	62.66
Plat 4, ...	759	189	570	24.90	75.10
Plat 5, ...	625	185	440	29.60	70.40

Summary of Yield of Crop (1890 to 1896).

[Pounds.]

Plats.	**1890.** Potatoes.	**1891.** Wheat.	**1892.** Serradella.	**1893.** Corn.	**1894.** Barley.	**1895.** Rye.
Plat 1, ...	1,600	380	4,070	1,660	490	695
Plat 2, ...	1,415	340	3,410	1,381	405	630
Plat 3, ...	1,500	215	2,750	1,347	290	383
Plat 4, ...	1,830	380	3,110	1,469	460	759
Plat 5, ...	2,120	405	2,920	1,322	390	625

Conclusions.

From the previous statement of comparative yield we find that the plat receiving dissolved bone-black leads in yield during the two first years, while for the third, fourth, fifth and sixth years the plats receiving insoluble phosphates are ahead, phosphatic slag being first, South Carolina floats second and Mona guano third.

The following statement regarding the amount of phosphoric acid applied in the case of each plat, and also the amount removed from them by the crops raised, shows approximately how much of the former is still stored up in the soil in each plat.

Phosphoric Acid applied to and removed from Field (Pounds).

PLATS.	1890. Potatoes.		1891. Wheat.		1892. Serradella.		1893. Corn.		Total Amount added.	Total Amount removed.	Total Amount remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1, .	24.18	2.56	24.18	1.23	24.18	8.95	24.18	7.20	96.72	19.94	77.78
Plat 2, .	28.01	2.36	28.01	1.19	28.01	7.50	28.01	6.33	72.04	17.38	54.66
Plat 3, .	109.68	2.40	–	.69	28.01	6.05	28.01	5.95	165.70	15.09	150.61
Plat 4, .	36.12	2.93	36.12	1.31	36.12	6.84	36.12	6.68	144.48	18.12	126.36
Plat 5, .	12.34	3.39	12.34	1.22	12.34	6.42	12.34	6.05	49.36	17.08	32.28

Phosphoric Acid applied to and removed from Field (Pounds) — Concluded.

PLATS.	1894. — Barley.		1895. — Rye.		Total Amount added.	Total Amount removed.	Total Amount remaining.
	Added.	Removed.	Added.	Removed.			
Plat 1, ...	None.	1.92	None.	3.41	96.72	25.27	72.45
Plat 2, ...		1.64		3.04	72.04	22.06	49.98
Plat 3, ...		.76		2.06	165.70	17.91	147.79
Plat 4, ...		1.72		3.61	144.48	23.45	121.03
Plat 5, ...		1.49		3.11	49.36	21.68	27.68

The amount of phosphoric acid left in the soil at the close of the season of 1895 is lowest in Plat 5, where dissolved bone-black, the most costly phosphate used in the experiment, has served as its source. The experiment will be continued until a final answer is obtained.

4. Field Experiments to ascertain the Influence of Different Mixtures of Commercial Fertilizers on the Yield and General Character of Several Prominent Garden Crops.

The area devoted to the above-stated experiment is 198 feet long and 183 feet wide; it is subdivided into six plats of uniform size ($89\frac{1}{2}$ by 62 feet, or about one-eighth of an acre each). The plats are separated from each other and from the adjoining cultivated fields by a space of 5 feet of unmanured and unseeded yet cultivated land. They are arranged in two parallel rows, running from west to east. Nos. 1, 2 and 3 are along the north side of the field, beginning with No. 1 at its west end, while plats Nos. 4, 5 and 6 are located along its south side, beginning with Plat 4 on the west end. The soil is several feet deep, and consists of a light, somewhat gravelly loam, and was in a fair state of productiveness when assigned for the experiment here under consideration. The entire field occupied by the experiment is nearly on a level. Potatoes and a variety of forage crops had been raised upon it in preceding years. The manure applied since 1885 has consisted exclusively of fine-ground bone and muriate of potash, annually, 600 pounds of the former and 200 pounds of the latter per acre.

The observation with raising garden crops, by the aid of different mixtures of commercial manurial substances, here under special consideration, began upon plats Nos. 4, 5 and 6 during the spring of 1891, and upon plats 1, 2 and 3 during that of 1892.

The difference of the fertilizers applied consisted in the circumstance that different forms of nitrogen and potash were used for their preparation. All plats received essentially the same quantity of nitrogen, potash and phosphoric acid, and every one of them received its phosphoric acid in the same form, namely, dissolved bone-black. Some plats received their nitrogen supply in the form of organic animal matter, dried blood; others in the form of sodium nitrate, Chili saltpetre; others in the form of ammonium sulphate. Some plats received their potash in the form of muriate of potash (plats 1, 2, 3), and others (plats 4, 5, 6) in the form of the

highest grade of potassium sulphate (95 per cent.). The subsequent tabular statement shows the quantities of manurial substances applied to the different plats: —

Plats.	Annual Supply of Manurial Substances.	Pounds.
Plat 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

This proportion corresponds per acre to: —

	Pounds.
Phosphoric acid (available),	50.4
Nitrogen,	60.0
Potassium oxide,	120.0

A computation of the results of a chemical analysis of twenty prominent garden crops shows the following average relative proportion of the three above-stated ingredients of plant food: —

	Per Cent.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain, on the above-stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weights and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement

here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limits pays, as a rule, better than a scanty one, especially in the case of those crops which reach in a short period the desired state of maturity. The various mixtures of fertilizers used by me in the experiments under discussion provide by actual supply for one-half of the available nitrogen actually called for to meet the demand as above pointed out. A liberal cultivation of peas and beans cannot fail to benefit the nitrogen resources of the soil. The order of arrangement of the different crops within each plat was the same in all of them for the same year. They occupied, however, a different position relative to each other in successive years, to introduce, as far as practicable, a system of rotation of crops.

Order of arrangement of crops in plats: —

Celery.
Lettuce.
Spinach.
Beets.
Cabbages.
Tomatoes.
Potatoes.

Spinach.
Celery.
Lettuce.
Red Cabbage.
Beets.
Potatoes.
Beets.
White Cabbage.
Tomatoes.

Potatoes.
Beans.
Tomatoes.
Spinach.
Lettuce.
Onions.

Onions.
Corn.
Beans.
Tomatoes.

The results of the stated three years were summed up as follows in my annual report for 1894, to which I have to refer for details. From our observations extending over three years we arrived at the following conclusions: —

Potash in the form of sulphate has given the most satisfactory results, as compared with muriate, in the case of potatoes, tomatoes, lettuce and spinach, and with onions during the present season.

Nitrogen in the form of nitrate of soda has given us, without regard to the potash source, the most satisfactory returns in case of spinach, lettuce, potatoes and tomatoes, and onions during the present season.

1895. — During the last season my observations have been confined to the cultivation of

Onions (Danvers Yellow).
Sweet Corn (Crosby Early).
Beans (Bush Horticultural).
Tomatoes (Essex Hybrid).

The different plats were ploughed April 20, and the particular fertilizer applied broadcast April 25. The soil was subsequently carefully prepared by harrowing, etc., for seeding and planting. The tomato plants were raised under glass and transplanted into the field when of a suitable size, May 25. The remaining crops were seeded directly in the field, — the onions May 1, the corn and the beans May 11.

The former division of the field into six plats, each containing the same crop for trial, — onions, beans, sweet corn and tomatoes, — was continued; each plat received the same mixture of fertilizing ingredients, and in the same proportion, as in the preceding years: —

	Pounds.
Available phosphoric acid,	50
Available nitrogen,	60
Available potassium oxide,	120

As each of the six plats measured $89\frac{1}{2}$ by 62 feet, covering thus an area of 5,549 square feet, or about 100 square feet more than one-eighth of one acre, the following amount of each of the above-stated essential constituents of plant food was added to each of them: —

	Pounds.
Phosphoric acid, ...	7½
Potassium oxide, ...	15
Nitrogen, ...	6¼

The crops were planted across each plat, from north to south, in rows 62 feet in length; a corresponding number of rows of each crop was planted in each plat, and they were arranged in each case in the same order of succession, beginning on the west end: —

Onions (Danvers Yellow), eight rows.
Sweet corn (Crosby Early), four rows.
Beans (Bush Horticultural), nine rows.
Tomatoes (Essex Hybrid), two rows.

Onions.

The onions were sown in rows 14 inches apart May 1; they came up May 12. The young plants looked least satisfactory upon plats 1 and 4, and most promising upon plats 2 and 5, July 11. The crop was harvested on all plats October 5. Plats 2 and 5 yielded more than one-half of the entire marketable crop, while plats 1 and 5 yielded but one-fifteenth of it.

Yield of Onions (Pounds).

PLATS.	Marketable.	Small.	Scullions.	Total.
Plat 1, ...	None.	30	100	130
Plat 2, ...	630	165	10	805
Plat 3, ...	375	70	80	525
Plat 4, ...	125	180	65	370
Plat 5, ...	455	190	16	661
Plat 6, ...	390	52	90	532

Sweet Corn.

The corn was planted in rows 3 feet 3 inches apart, with 20 inches in the row, averaging 131 hills in each plat, May 11. The young plants came up May 27 quite uniformly on all plats.

July 11 the crop on Plat 1 looked lighter than on any of the rest. The canes were reduced to three in each hill before heading, and the tops removed after the ears were fully developed, to hasten on maturing of the crop. There is a marked difference in the results as far as Plat 1 is concerned, — organic nitrogen gives the highest results; in case of different forms of potash, Plat 3 and Plat 6.

Yield of Sweet Corn when husked (Pounds).

PLATS.	Ears.	Husks.	Stover with Tops.	Total Weight.
Plat 1,	98	10	95	203
Plat 2,	117	8	115	240
Plat 3,	125	11	137	273
Plat 4,	112	10	125	247
Plat 5,	103	8	112	223
Plat 6,	118	10	130	258

Moisture in ears 34 per cent., in stover 20 per cent., when weighed.

Beans.

The beans were planted in rows 3 feet 3 inches apart May 11. They came up May 29 and blossomed July 6. At that time the crop looked best on Plat 5. The beans were harvested on all plats August 13, stacked on poles for drying, and were threshed in October.

Yield of Beans (Pounds).

PLATS.	Beans.	Pods and Vines.	Total Weight.
Plat 1,	81	260	341
Plat 2,	105	200	305
Plat 3,	83	155	238
Plat 4,	115	210	325
Plat 5,	135	260	395
Plat 6,	95	175	270

Tomatoes (Essex Hybrid).

The tomato plants were started under glass and transplanted in the field when from seven to eight inches high, May 25. They were of a vigorous growth, and were placed four feet apart each way. Each plat was planted with two rows, each row containing twenty-one plants. They began blooming June 5, and looked healthy at that time in all plats, yet best in Plat 5. The yield of matured tomatoes in case of plats 4 and 5 exceeded that of plats 3 and 6 by fully one-third in weight. The total yield of the crop, on account of more favorable weather of the past season, as compared with that of 1894, exceeded the latter by more than one-half of its weight.

Yield of Tomatoes (Pounds).

[Forty-two plants in each plat.]

Date of Picking.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Total.
August 13,	10	11	12	18	5	19	75
August 16,	85	79	125	87	57	134	567
August 20,	100	109	101	136	115	116	677
August 23,	115	134	90	150	143	86	718
August 28,	50	122	77	102	116	110	577
September 3,	151	153	133	215	210	124	986
September 11,	70	80	40	127	164	43	524
September 20,	138	40	–	63	96	–	337
September 25,	28	93	–	33	90	–	244

Yield of Green Tomatoes left October 1 (Pounds).

Plat 1,	30
Plat 2,	52
Plat 3,	26
Plat 4,	54
Plat 5,	48
Plat 6,	24
Total,	234

Summary of Yield of Garden Crops raised under Corresponding Conditions from 1891 to 1896.

Spinach (Variety New Zealand).

[Pounds.]

PLATS.	1892.	1893.	1894.	Total.	Average per Year.
Plat 1 (two rows, 62 feet long), .	192	167½	101	460	153.3
Plat 2 (two rows, 62 feet long), .	233	182	216	631	210.5
Plat 3 (two rows, 62 feet long), .	202	180½	165	547	182.3
Plat 4 (two rows, 62 feet long), .	230	196	161¾	587	195.7
Plat 5 (two rows, 62 feet long), .	232	210	253	695	231.7
Plat 6 (two rows, 62 feet long), .	134	198½	113¾	446	148.7

Lettuce (Variety Hanson).

[Pounds.]

PLATS.	1892.	1893.	1894.	Total.	Average per Year.
Plat 1 (one row, 70 plants), .	41½	40½	29	111	37.0
Plat 2 (one row, 70 plants), .	36	42	52	130	43.3
Plat 3 (one row, 70 plants), .	43	46	36	125	41.7
Plat 4 (one row, 70 plants), .	76	62	50	188	62.7
Plat 5 (one row, 70 plants), .	60	70	68	198	66.0
Plat 6 (one row, 70 plants), .	36	55	33	124	41.3

Tomatoes (Variety Essex Hybrid).

[Pounds.]

PLATS.	1892.	1893.	1894.	1895.	Total.	Average per Year.
Plat 1 (two rows, 42 plants),	464	363	352	747	1,926	481.5
Plat 2 (two rows, 42 plants),	572	874½	559	821	2,826	706.5
Plat 3 (two rows, 42 plants),	466	807	458	578	2,309	577.3
Plat 4 (two rows, 42 plants),	515	818	604	931	2,868	717.0
Plat 5 (two rows, 42 plants),	593	978½	594	996	3,161	790.2
Plat 6 (two rows, 42 plants),	332	515	571	632	2,050	502.5

Beans (Bush Horticultural).

[Pounds.]

PLATS.	1894.	1895.	Total.	Average per Year.
Plat 1 (six rows), ...	45	54.0	99.0	49.5
Plat 2 (six rows), ...	32	70.0	102.0	50.1
Plat 3 (six rows), ...	41	55.5	96.5	48.2
Plat 4 (six rows), ...	20	67.7	87.7	43.8
Plat 5 (six rows), ...	37	90.0	127.0	63.5
Plat 6 (six rows), ...	49	63.3	112.3	56.1

Onions (Danvers Yellow Globe).

[Pounds.]

PLATS.	1894.	1895.	Total.	Average per Year.
Plat 1 (four rows), . . .	156	65.0	221.0	110.5
Plat 2 (four rows), . . .	249	402.5	651.5	325.7
Plat 3 (four rows), . . .	251	262.5	513.5	256.7
Plat 4 (four rows), . . .	256	185.0	441.0	220.5
Plat 5 (four rows), . . .	266	330.5	596.5	298.3
Plat 6 (four rows), . . .	204	265.5	469.5	234.8

Conclusions.

1. Sulphate of potash in connection with nitrate of soda (Plat 5) has given in every case but one (onions) the best results.

2. Nitrate of soda as nitrogen source (plats 2 and 5) has yielded in every case, without reference to the form of potash, the best returns.

3. Sulphate of ammonia as nitrogen source, in connection with muriate of potash as potash source (Plat 1), has given as a rule the least satisfactory returns.

4. The influence of the difference in the general character of the weather, whether normal or dry, during succeeding seasons on the yield of the crops has been greater than that of the different fertilizers used upon different plats during the same season.

5. Field Experiments to study the Effect of Phosphatic Slag and Nitrate of Soda, as compared with Ground Bone, on the Yield of Oats and Corn.

The field used for this experiment is situated along a gently sloping ground, in the south-east corner of the farm. The soil consists of a sandy loam, and has been for several years under a careful system of cultivation and manuring. The productiveness was considered of uniform character when the experiment was planned in 1893. The area engaged in the observation was divided into two plats running along the slope from north to south. One plat, situated along the east side of the field, measured one acre (Plat 1); Plat 2 was situated along the west side of the field and measured one and nine-tenth acres.

Plat 1 was fertilized with 600 pounds of fine-ground bone and 200 pounds of muriate of potash per acre; Plat 2 was fertilized with 800 pounds of fine-ground phosphatic slag (odorless phosphate), 200 pounds of muriate of potash and 200 pounds of nitrate of soda per acre.

The amounts of manurial ingredients used per acre correspond to (in pounds): —

	Plat 1 (Bone).	Plat 2 (Phosphatic Slag).
Potassium oxide,	104	104
Phosphoric acid,	131	166
Nitrogen,	24	31

Composition of Fertilizer applied (Per Cent.).

	Nitrogen.	Phosphoric Acid.	Potassium Oxide.
Ground bone,	4.09	21.86	–
Phosphatic slag,	–	20.84	–
Muriate of potash,	–	–	52.20
Nitrate of soda,	15.70	–	–

Cost of Fertilizer (1894).

Plat 1, bone and muriate of potash (per acre), $12.40.
Plat 2, phosphatic slag, muriate of potash and nitrate of soda (per acre), $15.70.

1894. — As the east side of the field was on a higher level than the west side, it was decided to run the crop across the two plats from east to west, to secure as far as practicable corresponding conditions of the layout of the area occupied by the crops. The northern half of the field thus divided (plats 1 and 2) measured one acre, the southern half one and nine-tenths acres.

Oats and corn (variety Pride of the North) were selected for our observations. The oats were sown broadcast, at the rate of 4 bushels per acre, upon the northern portion of the field, and the corn was planted in rows 3 feet 3 inches apart, with hills 20 inches from each other, upon the southern portion, using 12 quarts of seed corn per acre. The area occupied by oats amounted to .35 of an acre of Plat 1 and .65 of an acre of Plat 2; while the corn occupied .7 of an acre of Plat 1 and 1.2 acres of Plat 2.

Summary of Yield (1894).

[Pounds per Acre.]

	Plat 1 (Bone, etc.).	Plat 2 (Odorless Phosphate, etc.).
Oats, grain, ...	531	876
Oats, straw, ...	1,640	2,385
Corn, for ensilage, ...	16,294	20,608

To test the reliability of the results obtained, it was decided to repeat the experiments above described upon the same field. The fertilizers were used in the same proportion and in the same quantity per acre; they were applied upon the same portion of the field which had received each kind before. Oats and corn were again selected as crops for the trial. The material change in the experiment consisted in reversing the location of the crops; the corn was planted at

the north end of the field, where the oats had been raised during the preceding season, and the oats were raised at the south end of the field, the part previously occupied by the corn. The oats were cut for hay when well headed out, and the corn when fully matured, for grain and stover.

Summary of Yield (1895).

[Pounds per Acre.]

	Bone and Muriate of Potash.	Phosphatic Slag, Nitrate of Soda, Muriate of Potash.
Oats, hay,	3,580	5,134
Corn, ears,*	3,410	4,231
Corn, stover,†	2,900	3,091

* Moisture, 28 per cent. † Moisture, 19.1 per cent. when harvested.

Conclusions.

The difference in the yield of oats and corn for two succeeding seasons points in the same direction; namely, phosphatic slag used in connection with nitrate of soda is a very efficient substitute for ground bone. To what extent these results, in our case, have to be ascribed to the presence of an excess of lime in the phosphatic slag, as compared with ground bone, is to be determined by a future actual trial.

6. Experiments with a Rotation of Manures upon Permanent Grass Lands, Meadows and Pastures.

One of the many advantages derived from the introduction of commercial fertilizers and chemicals for manurial purposes into general farm practice consists in the circumstance that in many instances a change with reference to the general character of the manure applied has served efficaciously as a substitute for a change of crops. The improved chances in compounding the manures to suit special requirements of soil and crops have, to say the least, greatly modified current views regarding the desirability or necessity of a rotation of crops in the interest of economy. The beneficial results noticed in other connections, due to a change in the general character of the manurial substances used, in case of the same land and in connection with the same crops, caused the arrangement of the experiments described upon a few subsequent pages.

Permanent grass lands are apt to suffer in the course of time from an accumulation of half-decayed vegetable matter, which is liable sooner or later to interfere with a healthy growth. To counteract this tendency it was decided to manure meadows alternately by top-dressing with barn-yard manure, or bone and muriate of potash, or wood ashes. The liberal amount of carbonate of lime, from 30 to 40 per cent., contained in the current supply of unleached wood ashes, was to serve as the means to hasten on the decomposition of the accumulating vegetable matter, and thereby secure favorable conditions for a healthy growth of valuable forage plants.

The meadows under consideration comprise an area of about 9.6 acres. The entire field up to 1886 consisted of old, worn-out grass lands, overrun with a worthless growth on its more elevated portion and covered with weeds and sedges in its lower swampy portion. The improvement of the land by underdraining was commenced in 1886 and continued during the succeeding year. For details of the work, see ninth and tenth annual reports (1891–92).

In the spring of 1893 a change was made in the mode of manuring of the grass plats. It was decided to study the

effect of a rotation of the three kinds of manures: barn-yard manure, bone and muriate of potash and Canada wood ashes, which had been applied for several years previous in succession and upon the same portion of the fields. The area was divided into three plats, Plat 1 (3.97 acres), Plat 2 (2.59 acres) and Plat 3 (3 acres). The system of manuring adopted was as follows: —

Plat 1, wood ashes, 1 ton per acre.

Plat 2, barn-yard manure, 8 tons per acre.

Plat 3, fine-ground bone 600 pounds, and muriate of potash 200 pounds, per acre.

The barn-yard manure was applied broadcast late in autumn, the others early in the spring.

1895. — The above arrangement of plats was continued during that season, and fertilizers were applied in the same proportion to the same plats.

Summary of Yield of Hay (Tons).

	Rate per Acre (Tons).		
	First Cut.	Second Cut, "Rowen."	Total.
1893.			
Plat 1, wood ashes, 1 ton per acre,	2.28	.77	3.05
Plat 2, barn-yard manure, 8 tons per acre,	2.62	.86	3.48
Plat 3, 600 pounds ground bone and 200 pounds muriate of potash per acre,	1.94	.64	2.58
1894.			
Plat 1, wood ashes, 1 ton per acre,	2.50	.37	2.87
Plat 2, barn-yard manure, 8 tons per acre,	2.86	.51	3.37
Plat 3, 600 pounds ground bone and 200 pounds muriate of potash per acre,	2.54	.18	2.72
1895.			
Plat 1, 600 pounds ground bone and 200 pounds muriate of potash per acre,	2.18	1.60	3.14
Plat 2, wood ashes, 1 ton per acre,	2.17	1.44	3.12
Plat 3, barn-yard manure, 8 tons per acre,	3.02	1.04	3.13

The season of 1894 was marked by a severe drought, beginning with the month of July and extending into the fall, which affected the yield of the crop (second cut) to a serious extent. The season of 1895 was a fair one for farm work in our section of the country.

Part II.

REPORT ON THE WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. On Official Inspection of Commercial Fertilizers in 1895.

During the past year fifty-five manufacturers and dealers in commercial fertilizers and agricultural chemicals have applied for and secured licenses for the sale of their goods in the State; twenty-seven of them being residents of Massachusetts, and the remainder belonging to Vermont, Rhode Island, Connecticut, New York, New Jersey, Maryland, Pennsylvania, Illinois, Ohio and Canada.

The number of different brands collected in the general market amounted to two hundred and ninety. The sampling and collecting of the material for analysis were in charge of Mr. H. D. Haskins, an efficient assistant in the chemical laboratory of the division of chemistry of the station, who for several years past has attended to that part of the inspection in a very satisfactory manner. Two hundred and seventy samples of the various brands collected by him were carefully analyzed, and the results obtained in that direction have been published and distributed in five special bulletins, *i. e.*, No. 57 old series and Nos. 30, 31, 32 and 34 of the Hatch station series.

The results of the inspection have been on the whole quite satisfactory, as far as the compliance of the dealers with the provision of our State laws for the regulation of the trade in commercial fertilizers is concerned. The variations here and there noticed between the guaranteed composition of the dealer and the results of our analyses could be traced with

but few exceptions to imperfect mixing of the several ingredients of the fertilizer, and did not, as a rule, materially affect the commercial value of the article. In this connection attention should be called to the fact that the lowest amount stated in the guarantee is only legally binding. As our State law makes allowance for these circumstances, the results of our examinations have been published without further comment. When deemed best for the interest of all parties concerned, the results have been sent by letter to the manufacturers of the goods, for their guidance and consideration. To convey a more direct idea of the actual value of this feature in the trade of commercial fertilizers of 1895, the following detailed statement is here inserted : —

(*a*) Where three essential elements of plant food were guaranteed : —

Number with three elements equal to or above the highest guarantee,	5
Number with two elements above the highest guarantee,	11
Number with one element above the highest guarantee,	49
Number with three elements between the lowest and highest guarantees,	45
Number with two elements between the lowest and highest guarantees,	54
Number with one element between the lowest and highest guarantees,	27
Number with two elements below the lowest guarantee,	6
Number with one element below the lowest guarantee,	30

(*b*) Where two essential elements of plant food were guaranteed : —

Number with two elements above the highest guarantee,	1
Number with one element above the highest guarantee,	11
Number with two elements between the lowest and highest guarantees,	17
Number with one element between the lowest and highest guarantees	7
Number with one element below the lowest guarantee,	10

(*c*) Where one essential element of plant food was guaranteed : —

Number above the highest guarantee,	4
Number between the lowest and highest guarantees,	21
Number below the lowest guarantee,	6

The consumption of commercial fertilizers is steadily increasing, a circumstance apparently not less due to a more general recognition of their good services, if judiciously selected and applied, than to gradual improvements in regard to their mechanical condition as well as their general chemical character. A noticeable change regarding the chemical composition of many brands of so-called complete or formula fertilizers of to-day, as compared with those offered for similar purposes at an earlier period in the history of the trade in commercial fertilizers, consists in a more general and more liberal use of potash compounds as a prominent constituent. This change has been slow but decided, and may in a large degree be ascribed to the daily increasing evidence, resting on actual observations in the field and garden, that the farm lands of Massachusetts are quite frequently especially deficient in potash compounds, and consequently need in many instances a more liberal supply of available potash from outside sources to give satisfactory returns. Whenever the cultivation of garden vegetables, fruits and forage crops constitutes the principal products of the land, this recent change in the mode of manuring deserves in particular a serious trial; for the crops raised consume exceptionally large quantities of potash, as compared with grain crops. In view of these facts, it will be conceded that a system of manuring farm and garden, which tends to meet more satisfactory recognized conditions of large areas of land as well as the special wants of important growing branches of agricultural industries, is a movement in the right direction. A judicious management of the trade in commercial fertilizers implies a due recognition of well-established experimental results regarding the requirements of a remunerative production of farm and garden crops.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in This State during the Past Year (May 1, 1895, to May 1, 1896), and the Brands licensed by Each.

Armour & Co., Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- All Soluble.
- Bone, Blood and Potash.

H. J. Baker & Bro., New York, N. Y.: —
- Standard Unexcelled Fertilizer.
- Strawberry Manure.
- Complete Onion Manure.
- Complete Potato Manure.
- Complete Tobacco Manure.
- Complete Grass and Lawn Manure.
- Complete Corn Manure.
- A A Ammoniated Superphosphate.
- Strictly Pure Ground Bone.
- Vegetable and Vine Fertilizer.

C. A. Bartlett, Worcester, Mass.: —
- Complete Animal Fertilizer.
- Pure Ground Bone.

Bowker Fertilizer Company, Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Fish and Potash.
- Bowker's Potato and Vegetable Manure.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Bone Phosphate.
- Bowker's Gloucester Fish and Potash.
- Bowker's Dry Ground Fish.
- Bowker's Fresh Ground Bone.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.
- Sulphate of Ammonia.

Bradley Fertilizer Company, Boston, Mass.: —
Bradley's X L Superphosphate.
Bradley's Potato Manure.
Bradley's B D Sea-fowl Guano.
Bradley's Complete Manures.
Bradley's Fish and Potash.
Bradley's High-grade Tobacco Manure.
Bradley's English Lawn Dressing.
Farmers' New-method Fertilizer.
Breck's Lawn and Garden Dressing.
Eclipse Phosphate.
Dry Ground Fish.
High-grade Sulphate of Potash.
Low-grade Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Sulphate of Ammonia.
Dissolved Bone-black.
Fine-ground Bone.

Wm. J. Brightman & Co., Tiverton, R. I.: —
High-grade Potato and Root Manure.
Brightman's Phosphate.
Brightman's Fish and Potash.

Bryant, Brett & Simpson, New Bedford, Mass.: —
Ground Bone.

B. L. Bragg & Co., Springfield, Mass.: —
Hampden Lawn Dressing.

Dan. T. Church, Providence, R. I.: —
Church's B Special Fertilizer.
Church's D Fish and Potash.
Church's C Standard.

Clark's Cove Fertilizer Company, Boston, Mass.: —
Bay State Fertilizer.
Bay State Potato Manure.
Great Planet Manure.
Fish and Potash.
King Philip Guano.
White Oak Pure Ground Bone.

Clark's Cove Fertilizer Company, Boston, Mass. — *Concluded.*
- Bay State Fertilizer, G G Brand.
- Potato and Tobacco Fertilizer.
- Tobacco Fertilizer.
- Blood, Bone and Meat.
- Dissolved Bone-black.
- Double Manure Salts.
- Sulphate of Potash.
- Muriate of Potash.
- Nitrate of Soda.

Cleveland Dryer Company, Boston, Mass.: —
- Cleveland Superphosphate.
- Potato Phosphate.
- Corn and Grain Phosphate.
- Fertilizer.
- High-grade Complete Manure.

E. Frank Coe Company, New York, N. Y.: —
- Gold Brand Excelsior Guano.
- High-grade Ammoniated Bone Superphosphate.
- Special Potato Fertilizer.
- Fish and Potash.
- High-grade Potato Fertilizer.

Crocker Fertilizer and Chemical Company, Buffalo, N. Y.: —
- Special Potato Fertilizer.
- Ammoniated Bone Superphosphate.
- Ammoniated Wheat and Corn Phosphate.
- New Rival Ammoniated Superphosphate.
- Potato Hop and Tobacco Phosphate.
- Ground Bone Meal.
- Practical Ammoniated Superphosphate.
- Pure Ground Bone.
- Vegetable Bone Superphosphate.

Cumberland Bone Phosphate Company, Boston, Mass.: —
- Superphosphate.
- Potato Fertilizer.
- Fertilizer.
- Concentrated Phosphate.
- Fine-ground Bone.

L. B. Darling Fertilizer Company, Pawtucket, R. I.: —
Animal Fertilizer.
Extra Bone Phosphate.
Potato and Root Fertilizer.
Lawn and Garden Manure.
Tobacco Grower.
Pure Fine Bone.
Pure Dissolved Bone.
High-grade Sulphate of Potash.

John C. Dow & Co., Boston, Mass.: —
Dow's Ground Bone Fertilizer.
Dow's Nitrogenous Superphosphate.
Dow's Pure Ground Bone.

Eastern Farm Supply Association, Montclair, N. J.: —
Carteret Farm Manure.
Carteret Potato Manure.
Carteret Corn and Grain Manure.
Carteret Market-garden Manure.

Forest City Wood Ash Company, Boston, Mass.: —
Unleached Hard-wood Ashes.
Odorless Mineral Guano.

Wm. E. Fyfe & Co., Clinton, Mass.: —
Canada Ashes.

Great Eastern Fertilizer Company, Rutland, Vt.: —
Great Eastern Soluble Bone and Potash.
Great Eastern Grain and Grass.
Great Eastern Oats, Buckwheat and Seeding-down.
Great Eastern Vegetable Vine and Tobacco.

Edmund Hersey, Hingham, Mass.: —
Ground Bone.

John G. Jefferds, Worcester, Mass.: —
Animal Fertilizer.
Potato Fertilizer.
Ground Bone.

A. Lee & Co., Lawrence, Mass.: —
Lawrence Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass. : —
Tankage.

Lowell Rendering Company, Chelmsford, Mass. : —
Lowell Bone Fertilizer.

The Mapes Formula and Peruvian Guano Company, New York, N. Y. : —
Mapes' Bone Manures.
Mapes' Superphosphates.
Mapes' Special Crop Manures.
Mapes' Peruvian Guano.
Mapes' Economical Manure.
Sulphate of Potash.
Double Manure Salts.
Nitrate of Soda.

Mason, Chapin & Co., Providence, R. I. : —
Chemical Compound Corn Fertilizer.
Chemical Compound Lawn Fertilizer.
Chemical Compound Vegetable Fertilizer.
Chemical Compound Tobacco Fertilizer.
Lawn and Grass Fertilizer.

McQuade Bros., Worcester, Mass. : —
Pure Ground Bone.

Monroe, Lalor & Co., Oswego, N. Y. : —
Canada Unleached Hard-wood Ashes.

Robert L. Merwin & Co., New York, N. Y. : —
Albert's Highly Concentrated Horticultural Manure.

National Fertilizer Company, Bridgeport, Conn. : —
Ammoniated Bone Phosphate.
Chittenden's Complete Fertilizer.
Fish and Potash.
Ground Bone.

New England Dressed Meat and Wool Company, Boston, Mass. : —
Sheep Fertilizer.

Niagara Fertilizer Company, Buffalo, N. Y. : —
Niagara Triumph.
Niagara Grain and Grass Grower.
Niagara Wheat and Corn Producer.
Niagara Potato, Tobacco and Hop Fertilizer.

Pacific Guano Company, Boston, Mass.: —
- Soluble Pacific Guano.
- Special Potato Fertilizer.
- Special for Potatoes and Tobacco.
- High-grade General Fertilizer.
- Fish and Potash.
- Muriate of Potash.
- Dissolved Bone-black.
- Nitrate of Soda.
- Sulphate of Potash.

John J. Peters & Co., Long Island City, N. Y.: —
- Sheep Fertilizer.

Parmenter & Polsey Fertilizer Company, Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato Fertilizer.
- Star Brand Superphosphate.
- Ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

Prentiss Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Tankage.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.
- Fish and Potash.
- Fish.

Quinnipiac Company, Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Onion Manure.
- Havana Tobacco Fertilizer.
- Corn Fertilizer.
- Market-garden Manure.
- Potato and Tobacco Manure.
- Fish and Potash, "Crossed Fishes."
- Fish and Potash, "Plain Brand."
- Grass Fertilizer.

Quinnipiac Company, Boston, Mass. — *Concluded.*
Pure Bone Meal.
Dry Ground Fish.
Strawberry Manure.
Ammoniated Dissolved Bones.
Nitrate of Soda.
Sulphate of Potash.
Muriate of Potash.
Double Manure Salts.

Read Fertilizer Company, New York, N. Y. : —
Read's Standard.
High-grade Farmers' Friend.
Fish and Potash.
Vegetable and Vine.

N. Roy & Son, South Attleborough, Mass. : —
Animal Fertilizer.

The Rogers & Hubbard Company, Middletown, Conn. : —
Pure Ground Raw Knuckle Bone Meal.
Strictly Pure Fine Bone.
Fertilizer for Oats and Top-dressing.
Soluble Potato Manure.
Fairchild's Formula for Corn and General Crops.
Soluble Tobacco Manure.
Grass and Grain Fertilizer.

Russia Cement Company, Gloucester, Mass. : —
Essex Complete Manure for Potatoes and Roots.
Essex Complete Manure for Corn and Grain.
Essex Perfected Lawn Dressing.
Essex Special Vegetable Manure.
Essex High-grade Fish and Potash.

Lucien Sanderson, New Haven, Conn. : —
Formula "A."
Bone, Meat and Blood.
Dissolved Bone-black.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.

Edward H. Smith, Northborough, Mass. : —
Ground Bone.

Springfield Provision Company, Brightwood, Mass. : —
Blood, Meat and Bone.

Standard Fertilizer Company, Boston, Mass. : —
Complete Manure.
Potato and Tobacco Manure.
Fertilizer.
Guano.
Fish and Potash.
Fine-ground Bone.
Muriate of Potash.
Dissolved Bone-black.

T. L. Stetson, Randolph, Mass. : —
Pure Ground Bone.

F. C. Sturtevant, Hartford, Conn. : —
Ground Tobacco Stems.

Charles Stevens, Napanae, Ontario, Can. : —
Unleached Hard-wood Ashes.

Henry F. Tucker, Boston, Mass. : —
Tucker's Original Bay State Bone Superphosphate.
Tucker's Imperial Bone Superphosphate.
Tucker's Special Potato Fertilizer.

Thompson & Edwards Fertilizer Company, Chicago, Ill. : —
Pure Fine-ground Bone.

Walker, Stratman & Co., Pittsburg, Pa. : —
Potato Special.
Smoky City.
Big Bonanza.
Four Fold.

M. E. Wheeler & Co., Rutland, Vt. : —
High-grade Fruit Fertilizer.
Grass and Oats Fertilizer.
Electrical Dissolved Bone.
Potato Manure.
High-grade Corn Fertilizer.

Leander Wilcox, Mystic, Conn. : —
- Potato, Onion and Tobacco Manure.
- Ammoniated Bone Phosphate.
- Fish and Potash.
- Dry Ground Fish.

Williams & Clark Fertilizer Company, Boston, Mass. : —
- Americus Ammoniated Bone Superphosphate.
- Potato Phosphate.
- Grass Manure.
- Pure Bone Meal.
- High-grade Special.
- Corn Phosphate.
- Fine Wrapper Tobacco Fertilizer.
- Universal Ammoniated Dissolved Bone.
- Fish and Potash.
- Dry Ground Fish.
- Potato and Tobacco Manure.
- Royal Bone Phosphate.
- Onion Manure.
- Dissolved Bone-black.
- Nitrate of Soda.
- Double Manure Salts.
- Sulphate of Potash.
- Muriate of Potash.

2. General Work in the Laboratory of the Division of Chemistry.

The work in the chemical laboratory of the united stations has been divided by a recent vote of the board of trustees between the newly created division of "Foods and Feeding" and the "Division of Chemistry." The separate operation of the two divisions dates from July 1, 1895. The analyses of feeds stuffs, dairy products and well waters made before that date are incorporated in the annual report of Dr. J. B. Lindsey, who by vote of the trustees has been placed in charge of the new division of foods and feeding, which includes in its scope the examination of these substances.

Aside from the supervision of the inspection of commercial fertilizers, the results of which are discussed in a few preceding pages, my attention has been divided between the direction of a series of experiments in the field and vegetation house, introduced some years ago for the purpose of studying the economy of various systems of manuring and raising field and garden crops, and an extensive correspondence with farmers and others, asking for information regarding a variety of subjects of interest to them. The description of the former constitutes the first part of this report. The results of the examination of many manurial substances sent on for that purpose in connection with the latter, whenever of general interest, have been published during the past year in the bulletins of the station. They are also recorded in connection with the tabular compilation of analyses of manurial substances which accompanies this report.

The constantly increasing variety of waste products of many branches of industry within our State and elsewhere which have proved of manurial value, has received for years a serious attention. Both producers and consumers have been materially benefited by this work, which aims to make known the particular fitness of each for manurial purposes, and thereby furnishes a basis for the determination of its commercial value. As a change in the current modes of manufacture of the parent industry is at any time liable to

seriously affect the character and chemical composition of the waste or by-products, it becomes necessary to repeat from time to time analyses of many of these products. These analyses are made without any charge for the work, on the condition that the results are public property, if deemed of interest for publication.

As a brief enumeration of the more prominent substances sent on for our investigation during the year 1895 can best convey a correct idea concerning the extent and importance of the labor involved, the following statement is presented: the whole number of analyses made in the stated connection amounts for the year 1895 to one hundred and eighty-six; of these, from eighty to ninety consisted of ashes, including wood ashes, coal ashes, lime-kiln ashes, cotton-hull ashes, swill ashes, soots, etc ; from twenty to thirty were agricultural chemicals, comprising potash salts, Chili saltpetre, sulphate of ammonium, gypsum, kainites, dissolved bone-black, phosphatic slag, etc.; twenty-eight were animal refuse materials, as fish waste, tankage, blood, animal meal, meat scraps, blood and bone, bones, wool waste, sheep fertilizer, etc.; and from twenty to thirty consisted of vegetable refuse materials, as cotton-factory waste, cotton-seed meal, tobacco stems, madder, peats, vegetable compost, etc.

Of a special interest is the recent introduction of the products prepared from the kitchen refuse of our large cities. Sanitary considerations are indirectly the cause of the appearance of these products, which promise to become of considerable prominence in the future.

One mode disposes of the refuse by cremation. The product resulting is called cremation ashes, and contains a liberal amount of phosphate of lime and more or less potash. The nitrogen and organic matter are lost in the process of cremation. Grinding and proper mixing of the products cannot fail to furnish a valuable material for manurial purposes. The tabular statement below gives the results of analyses of swill or cremation ashes, mostly if not entirely from Lowell, Mass.

Another mode proposes to save the nitrogen and organic matter by a so-called reduction process. The parties in-

terested in the matter propose to reduce the garbage with sulphuric acid, remove the fat, add to the refuse natural phosphates to combine with the excess of sulphuric acid, and add potash compounds if needed. This interesting process is apparently still in the experimental stage. A sample of the product sent here for examination gives the results found below. Modern views regarding the requirements of sanitary condition in our centres of population cannot fail to recognize the efficiency of both processes to dispose of objectionable material. The economical advantages derived from these modes of operation experience alone can determine. The product of either mode has its special claim for consideration. The agricultural interests of the country cannot fail to benefit by a successful development of either mode of operation.

Analyses of Ashes from a Crematory Furnace, Lowell, Mass.

	1.	2.	3.	4.	5.	6.	7.
Moisture at 100° C.,	0.51	0.07	0.04	0.11	2.43	19.46	12.48
Potassium oxide,	1.73	8.83	7.03	1.25	1.59	1.78	3.35
Phosphoric acid,	16.61	17.18	26.09	32.26	25.89	5.22	6.50
Calcium oxide,	24.79	28.18	33.74	47.60	-*	-*	-*
Ferric and aluminic oxides,	3.56	7.63	6.25	1.06	-*	-*	-*
Magnesium oxide,	1.87	-*	-*	-*	-*	-*	-*
Insoluble matter before calcination,	39.60	18.49	14.40	15.13	-*	-*	-*
Insoluble matter after calcination,	29.72	16.53	11.41	13.20	17.93	30.81	31.54

	8.	9.	10.	11.	12.	13.	14.
Moisture at 100° C.,	0.37	7.57	14.24	8.05	1.20	1.19	0.87
Potassium oxide,	4.27	3.96	5.09	4.92	5.71	4.83	4.08
Phosphoric acid,	12.97	13.92	6.86	13.22	10.82	10.21	71.47
Insoluble matter after calcination,	34.91	19.96	37.76	24.52	29.91	24.50	26.73

* Not determined.

Analysis of a Refuse Product obtained from City Garbage, sent on by the American Reduction Company, New York City.

	Per Cent.
Moisture at 100° C.,	8.52
Nitrogen,	1.64
Potassium oxide,	1.20
Sodium oxide,	2.50
Calcium oxide,	3.86
Magnesium oxide,	.55
Ferric and aluminic oxides,	7.64
Total phosphoric acid,	10.62
Available phosphoric acid,	8.08
Insoluble phosphoric acid,	2.54
Sulphuric acid,	8.54
Organic matter,	45.43
Insoluble matter (ash),	12.15

3. Compilation of Analyses made at Amherst, Mass., of Agricultural Chemicals and Refuse Materials used for Fertilizing Purposes.

Prepared by H. D. Haskins.

[As the basis of valuation changes from year to year, no valuation is stated.]

1868 to 1896.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the reports of the State Inspector of Fertilizers from 1873 to 1896, contained in the reports of the Secretary of the Massachusetts State Board of Agriculture for those years.

C. A. G.

	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc.																							
Muriate of potash,	79	1.80	-	-	-	-	58.98	45.94	51.02	-	-	-	-	-	-	6.69	-	.55	-	-	-	48.80	.70
Sulphate of potash,	32	2.12	-	-	-	-	51.30	21.36	38.67	-	-	-	-	-	-	4.46	-	1.50	-	45.72	-	-	.75
Sulphate of potash-magnesia,	26	4.85	-	-	-	-	29.48	16.96	24.82	-	-	-	-	-	-	6.25	2.57	-	-	44.25	-	2.60	1.41
Carbonate of potash,	1	26.88	-	-	-	-	-	-	18.48	-	-	-	-	-	-	-	-	19.52	-	-	-	-	.39
Phosphate of potash,	1	3.76	-	-	-	-	-	-	32.56	-	-	37.50	-	-	-	-	-	-	-	13.43	-	-	.92
Kainite,	5	3.18	-	-	-	-	16.48	12.51	13.56	-	-	-	-	-	-	18.97	1.15	9.80	-	20.25	-	33.25	2.13
Carnallite,	1	-	-	-	-	-	-	-	13.68	-	-	-	-	-	-	7.66	-	13.19	-	.56	-	41.56	-
Krugite,	1	4.82	-	-	-	-	-	-	8.42	-	-	-	-	-	-	5.27	12.45	8.79	-	31.94	-	6.63	14.96
Sulphate of magnesia (Kieserite),	9	22.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.82	17.30	-	36.10	-	-	5.73
Nitrate of potash,	4	1.30	-	14.58	11.60	12.71	45.62	44.76	45.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate of soda,	36	1.42	-	16.22	14.28	15.02	-	-	-	-	-	-	-	-	-	35.50	-	-	-	-	-	.50	.50
Sulphate of ammonia,	28	1.06	-	21.68	19.59	22.03	-	-	-	-	-	-	-	-	-	-	-	-	-	60.00	-	-	-
Phosphate of ammonia,	1	6.05	-	-	-	10.37	-	-	-	-	-	43.86	-	-	-	-	-	-	-	12.46	-	-	.82
Sulphate of soda,	1	1.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.43	-	-	-
Saltpetre waste,	12	2.54	-	8.30	.52	2.22	30.94	1.55	13.66	-	-	-	-	-	-	37.04	.75	.19	-	1.85	-	46.25	-

Nitre salt-cake,	2	6.03	-	-	-	2.29	-	-	.87	-	-	-	-	-	-	29.56	-	-	-	47.77	-	-	3.92
Wood ashes,	476	10.64	-	-	-	-	10.80	1.20	5.37	5.58	.05	1.52	-	-	-	-	33.58	3.31	.96	-	-	-	14.22
Cotton-seed-hull ashes,	49	8.21	-	-	-	-	42.12	9.91	22.77	13.67	2.89	8.15	-	-	-	-	9.30	10.47	1.76	-	-	-	13.44
Ashes of spent tan-bark,	5	4.84	-	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	-	-	31.11	3.39	1.78	-	-	-	25.21
Corn-cob ashes,	1	1.20	-	-	-	-	-	-	7.08	-	-	2.37	-	-	-	-	11.70	-	1.28	-	-	-	52.09
Railroad-tie ashes,	1	4.70	-	-	-	-	-	-	.92	-	-	.56	-	-	-	-	2.51	-	-	-	-	-	80.20
Peat ashes,	1	4.67	-	-	-	-	-	-	.46	-	-	.11	-	-	-	-	2.28	1.63	6.13	-	-	-	45.17
Logwood ashes,	1	1.50	-	-	-	-	-	-	.08	-	-	2.30	-	-	-	-	3.90	-	-	-	-	-	9.70
Hard-pine wood ashes,	1	.75	-	-	-	-	-	-	10.16	-	-	2.24	-	-	-	-	24.95	-	-	-	-	-	29.90
Mill ashes,	1	.53	-	-	-	-	-	-	1.60	-	-	.46	-	-	-	-	34.93	1.35	-	-	-	-	36.36
Ashes from cremation of swill,	14	4.89	-	-	-	-	8.83	1.25	4.17	32.36	7.47	14.66	-	-	-	-	33.58	1.87	4.65	-	-	-	19.73
Ashes from blue works,	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30
Sea-weed ashes,	1	1.47	-	-	-	-	-	-	.92	-	-	.30	-	-	-	8.76	6.06	4.37	-	2.98	-	6.60	63.65
Gypse,	1	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.87	-	-	-	-	-	2.87
Nova Scotia plaster (gypsum),	15	8.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.85	.75	-	45.12	-	-	3.47
Onondaga plaster (New York gypsum),	4	13.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.00	4.66	-	32.50	8.20	-	9.83
Lime,	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.63	-	-	-	-	-	1.33
Waste lime,	1	.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74.12	-	-	-	-	-	.38
Gas-house lime,	3	22.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.66	8.30	-	20.73	-	-	6.05
Lime waste from sugar factory,	1	36.30	-	-	-	-	-	-	.22	-	-	2.25	-	-	-	-	27.51	-	-	-	-	-	.32
Lime-kiln ashes,	17	14.48	-	-	-	-	2.78	.02	1.28	3.16	.36	1.09	-	-	-	-	42.57	2.60	-	-	17.75	-	7.69
Bituminous coal ashes,	1	7.18	-	-	-	-	-	-	.60	-	-	.43	-	-	-	-	-	-	-	-	-	-	68.50

	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
I. Chemicals, Refuse, Salts, Ashes, etc. — Concluded.																							
Marls (Massachusetts),	7	13.70	-	-	-	-	-	-	.24	2.72	.06	1.05	-	-	-	-	40.50	.64	.69	-	28.57	-	3.44
Marls (Virginia),	2	15.98	-	-	-	-	.61	.37	.49	.09	.08	.09	-	-	-	-	7.25	.21	-	.66	7.25	-	64.23
Green sand marl (Virginia),	1	1.25	-	-	-	-	-	-	1.14	-	-	9.37	-	-	-	-	25.78	-	5.13	-	-	-	41.32
Olive earth (Virginia),	1	1.97	-	-	-	-	-	-	.24	-	-	13.73	-	-	-	-	19.16	-	6.00	-	-	-	50.55
Ammoniated marl,	1	3.31	-	-	-	1.61	-	-	-	-	-	10.39	-	.41	9.98	-	-	-	-	-	-	-	-
Marl (North Carolina),	1	1.50	-	-	-	-	-	-	.04	-	-	.56	-	-	-	-	21.95	.61	-	-	-	-	50.18
Clay (so called),	1	.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	54.35	1.04	2.80	-	37.32	-	2.57
II. Guanos, Phosphates, etc.																							
Peruvian guano,	26	14.81	37.61	13.50	4.44	7.85	4.08	1.14	2.61	20.60	5.96	15.26	4.57	3.79	6.90	-	-	-	-	-	-	-	6.60
Bat guano from Texas,	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	-	-	-	2.00
Bat guano from Florida,	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	-	-	-	19.33
Rat guano from Florida,	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15
Cuban guano,	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	-	-	-	3.17
Caribbean guano (orchilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.11	26.77	-	-	-	-	39.95	3.29	-	2.68	-	-	1.27
Mona Island guano,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	-	-	-	2.45

South Carolina rock phosphate,	6	1.45	-	-	-	-	-	-	-	30.51	24.70	27.47	.27	.07	27.13	-	41.87	3.03	4.80	-	-	-	9.04
South Carolina floats,	1	.83	-	-	-	-	-	-	-	-	-	23.39	-	2.33	21.06	-	-	-	-	-	-	-	20.16
Florida rock phosphate,	29	2.09	-	-	-	-	-	-	-	38.97	6.95	26.15	-	-	-	-	30.40	-	7.56	-	-	-	27.29
Soft Florida phosphate,	3	4.87	-	-	-	-	-	-	-	19.94	17.71	18.73	-	-	-	-	23.72	-	6.82	-	-	-	20.92
Navassa phosphate,	2	7.60	-	-	-	-	-	-	-	34.45	34.09	34.27	-	-	-	-	37.45	-	10.27	-	-	-	2.70
Brockville phosphate,	1	2.50	-	-	-	-	-	-	-	-	-	35.21	-	-	-	-	-	-	-	-	-	-	6.46
Phosphatic slag,	4	1.45	-	-	-	-	-	-	-	30.51	18.91	23.49	-	3.06	21.65	-	48.66	3.42	10.12	-	-	-	9.40
Odorless phosphate,	6	2.99	-	-	-	-	.52	.04	.38	21.74	18.40	19.54	-	.52	19.82	-	51.42	-	-	-	2.51	-	9.14
Dissolved bone-black,	6	10.31	47.50	-	-	-	-	-	-	17.54	14.99	16.00	14.48	1.15	.37	-	-	-	-	-	-	-	3.99
Bone-black,	5	4.60	-	-	-	-	-	-	-	30.54	16.56	28.28	-	-	-	-	-	-	-	-	-	-	3.64
Double superphosphate,	1	5.74	-	-	-	-	-	-	-	-	-	47.80	38.38	9.04	.38	-	16.00	-	-	1.19	-	-	.60
South American bone-ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	4.50
Acid phosphate,	1	14.23	69.95	-	-	-	-	-	-	-	-	14.64	10.34	2.42	1.88	-	-	-	-	-	-	-	10.81
III. Refuse Substances.																							
Dried blood,	17	11.97	6.37	13.55	8.10	10.48	-	-	-	6.23	1.30	2.00	-	-	-	-	-	-	-	-	-	-	-
Ammonite,	1	5.88	-	-	-	11.33	-	-	-	-	-	3.43	-	-	-	-	-	-	-	-	-	-	1.38
Oleomargarine refuse,	1	8.54	14.42	-	-	12.12	-	-	-	-	-	.88	-	-	-	-	-	-	-	-	-	-	.96
Felt refuse,	1	29.24	33.53	-	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sponge refuse,	1	7.25	-	-	-	2.43	-	-	-	-	-	3.19	-	-	-	-	3.94	1.27	-	-	-	-	39.05
Blood and bone,	2	8.36	-	6.80	6.68	6.74	-	-	-	11.39	10.62	11.01	-	2.82	7.80	-	-	-	-	-	-	-	-
Horn shavings,	1	4.83	-	-	-	15.31	-	-	-	-	-	.42	-	-	-	-	-	-	-	-	-	-	-

	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
III. Refuse Substances — Continued.																							
Ivory dust,	1	11.50	52.63	-	-	6.64	-	-	-	-	-	24.56	.97	17.97	5.62	-	-	-	-	-	-	-	-
Horn and hoof waste,	3	10.17	7.63	15.49	11.84	13.25	-	-	-	2.30	1.36	1.83	-	-	-	-	-	-	-	-	-	-	.24
Raw wool,	1	6.95	7.54	-	-	12.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.63
Wool waste,	11	11.77	24.10	10.20	.96	4.56	3.50	.06	1.68	.67	.05	.31	-	-	-	-	.11	.06	.80	-	-	-	8.20
Wool washings (water),	1	-	-	-	-	-	-	-	3.92	-	-	-	-	-	-	.49	.28	-	-	-	-	-	-
Wool washings (acid),	1	-	-	-	-	-	-	-	4.20	-	-	-	-	-	-	.40	.61	.20	-	-	-	-	-
Wool washings (alkaline),	1	92.03	3.28	-	-	.09	-	-	1.09	-	-	-	-	-	-	.92	.04	-	-	-	-	-	.22
Morocco factory waste,	1	22.72	-	-	-	1.16	-	-	.36	-	-	2.56	-	-	-	-	19.60	-	-	1.24	-	-	24.17
Meat scrap,	2	24.79	-	-	-	6.33	-	-	-	-	-	5.79	-	-	-	-	-	-	-	-	-	-	-
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	-	-	-	3.58	.56	2.07	-	-	-	-	-	-	-	-	-	-	.58
Bone soup,	1	82.92	7.07	-	-	1.14	-	-	-	-	-	1.26	-	-	-	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	1	14.80	8.40	-	-	9.97	-	-	-	-	-	.53	-	-	-	-	-	-	-	-	-	-	.64
Dried soup from rendering cattle feet,	1	10.80	7.50	-	-	14.47	-	-	-	-	-	.46	-	-	-	-	-	-	-	-	-	-	.26
Dried soup from horse rendering,	1	92.14	-	-	-	1.12	-	-	-	-	-	.14	-	-	-	-	-	-	-	-	-	-	-
Soap-grease refuse,	2	29.25	51.39	4.20	2.21	3.21	-	-	-	15.37	11.04	13.21	-	-	-	-	-	-	-	-	-	-	1.29
Bones,	164	6.87	53.03	4.70	1.57	3.91	-	-	-	32.52	15.16	22.37	.38	8.22	13.74	-	-	-	-	-	-	-	1.08

Meat and bone,	2	5.26	-	-	-	4.57	-	-	-	-	-	20.21	.26	7.03	13.05	-	-	-	-	-	-	-	1.22
Tankage,	11	9.57	-	9.16	4.29	6.83	-	-	-	15.86	4.03	11.49	-	4.06	7.46	-	-	-	-	-	-	-	-
Fish with less than twenty per cent. water,	71	12.31	21.50	11.40	5.97	7.56	-	-	-	15.91	5.50	8.48	.55	2.64	5.06	-	-	-	-	-	-	-	2.01
Fish with between twenty and forty per cent. water.	10	30.19	20.59	7.41	4.22	5.97	-	-	-	8.32	4.68	7.09	.74	2.69	3.64	-	-	-	-	-	-	-	1.68
Fish with more than forty per cent. water,	10	45.46	15.50	7.60	2.43	4.97	-	-	-	8.56	2.94	5.08	1.17	1.33	2.58	-	-	-	-	-	-	-	1.35
Whale meat, raw,	1	44.50	1.04	-	-	4.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobster shells,	1	7.27	-	-	-	4.50	-	-	-	-	-	3.52	-	-	-	-	22.24	1.30	-	-	-	-	.27
Castor-bean pomace,	6	9.68	5.70	5.72	5.22	5.51	3.40	.64	1.57	2.26	1.57	2.18	-	-	-	-	.87	.29	-	-	-	-	1.75
Cotton-seed meal,	33	6.78	5.78	7.70	4.02	6.77	2.38	.48	1.77	3.36	.73	1.65	-	-	-	-	-	-	-	-	-	-	.28
Rotten brewers' grain,	1	78.77	-	-	-	.72	-		.04	-	-	.43		-	-	-	.26	.15	-	-	-	-	.59
Mill sweepings,	1	9.49	-	-	-	3.76	-	-	.66	-	-	1.18	-	-	-	-	-	-	-	-	-	-	5.01
Tobacco leaf,	1	13.05	21.01	-	-	2.75	-	-	7.24	-	-	.43	-	-	-	-	4.17	2.17	.32	-	-	-	4.17
Tobacco stems,	7	10.61	14.07	2.91	.90	2.30	10.60	3.76	7.03	2.09	.44	.62	-	-	-	.34	3.89	1.23	-	-	-	-	.82
Cotton waste, wet,	1	34.69	-	-	-	1.30	-	-	.80	-	-	1.54	-	-	-	-	2.45	1.13	-	-	-	-	41.33
Cotton waste, dry,	4	5.87	60.60	9.33	.96	1.77	1.76	.66	1.42	1.80	.26	.45	-	-	-	-	-	-	-	-	-	-	32.59
Refuse from calico works,	1	4.07	-	-	-	4.28	-	-	-	-	-	11.95	-	-	-	-	-	-	-	-	-	-	-
Cotton dust,	1	34.46	50.93	-	-	.50	-	-	.19	-	-	.21	-	-	-	-	.90	.90	-	-	-	-	47.46
Glucose refuse,	1	8.10	-	-	-	2.62	-	-	.15	-	-	.29	-	-	-	-	.18	.02	-	-	-	-	.07
Waste from lactate factory,	1	34.11	-	-	-	.68	-	-	-	-	-	.67	-	-	-	-	22.59	-	-	-	-	-	6.92
Hop refuse,	1	8.98	-	-	-	.98	-	-	.11	-	-	.20	-	-	-	-	.27	.10	-	-	-	-	.63
Banana skins,	1	13.99	-	-	-	.24	-	-	5.46	-	-	1.80	-	-	-	-	-	-	-	-	-	-	-
Tankage and blood,	1	14.43	-	-	-	5.88	-	-	-	-	-	6.84	5.44	1.08	.32	-	-	-	-	-	-	-	-

	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Concluded.																							
Sumac waste,	1	63.06	6.80	-	-	1.19	-	-	3.25	-	-	-	-	-	-	-	1.14	3.25	-	-	-	-	2.25
Eel-grass,	2	35.39	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	-	-	-	1.63	2.13	.11	-	-	-	-	1.06
Pine-barren grass,	1	8.48	2.40	-	-	.16	-	-	.07	-	-	.18	-	-	-	-	-	-	-	-	-	-	1.67
Pine needles,	1	9.48	3.42	-	-	.46	-	-	.03	-	-	.12	-	-	-	-	-	-	-	-	-	-	1.22
Rockweed, green,	1	68.50	23.70	-	-	.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	1	10.68	35.75	-	-	1.45	-	-	4.89	-	-	2.75	-	-	-	7.90	7.66	.21	-	-	-	-	10.40
Jute waste,	1	13.10	-	-	-	1.50	-	-	.08	-	-	.72	-	-	-	-	-	-	-	-	-	-	-
Hair waste,	1	72.81	-	-	-	1.39	-	-	.32	-	-	.61	-	-	-	-	-	-	-	-	-	-	-
Starch waste from rubber factory,	1	10.01	.23	-	-	.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge from sewage precipitating tanks,	1	88.49	9.50	-	-	.05	-	-	.05	-	-	.10	-	-	-	-	1.58	.39	6.22	-	-	-	.93
Sludge,	1	6.28	-	-	-	.68	-	-	-	-	-	1.36	-	-	-	-	8.66	-	17.68	-	-	-	38.03
Residue from water filter,	1	94.22	-	-	-	.12	-	-	-	-	-	.05	-	-	-	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*), dry,	1	16.26	-	-	-	4.25	-	-	.79	-	-	.19	-	-	-	3.53	2.06	1.18	-	-	-	-	5.53
Mussel mud, wet,	1	60.01	27.29	-	-	.21	-	-	6.17	-	-	.10	-	-	-	.70	.93	.14	3.48	-	-	-	-
Mussel mud, dry,	1	2.24	72.02	-	-	.72	-	-	-	-	-	.35	-	-	-	-	23.39	-	8.26	-	-	-	37.60
Madder,	2	11.93	-	-	-	.91	-	-	2.40	-	-	.35	-	-	-	-	3.93	.51	-	-	-	-	4.67

Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	-	-	-	-	-	-	.94	.91	.37	4.13	-	-	-	34.88
Fresh-water mud,	1	40.37	-	-	-	1.37	-	-	.22	-	-	.26	-	-	-	-	1.27	.29	1.80	-	-	-	18.26
Muck,	22	59.72	13.75	2.54	.26	.86	-	-	-	.17	.08	.13	-	-	-	-	-	-	-	-	-	-	11.35
Peat, wet,	11	61.36	7.66	1.40	.41	.85	-	-	.18	-	-	.09	-	-	-	-	.55	.72	2.14	-	-	-	2.14
Peat, dry,	2	14.67	17.26	-	-	1.89	-	-	.06	-	-	.03	-	-	-	-	-	-	-	-	-	-	10.14
Turf,	2	19.29	6.36	1.97	1.91	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soot,	7	4.29	77.10	1.05	.09	.41	1.83	.21	.63	2.10	.19	1.13	-	-	-	-	2.99	1.19	6.38	-	-	-	66.06
IV. Animal Excrement, etc.																							
Barn-yard manure,	76	67.01	-	1.36	.21	.52	1.40	.13	.56	.75	.10	.39	-	-	-	-	.30	.19	-	-	-	-	8.09
Horse manure,	1	11.24	-	-	-	.74	-	-	2.82	-	-	1.46	-	-	-	-	-	-	-	-	-	-	12.60
Sheep manure,	2	50.26	-	-	-	1.15	-	-	.64	-	-	.66	-	-	-	-	-	-	-	-	-	-	12.91
Drainage from a manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	-	.95	-	-	-	-	-	-	-	-	-	-	-
Hen manure, fresh,	2	52.35	24.75	1.20	.79	.99	.32	.18	.25	1.00	.47	.74	-	-	-	-	1.19	.89	-	1.24	-	-	23.50
Hen-house refuse,	1	3.43	-	-	-	.98	-	-	.60	-	-	1.28	-	-	-	-	-	-	-	-	-	-	-

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc.													
Muriate of potash,	36.	-	-	1020.	-	134.	-	11.	-	-	-	976.	14.
Sulphate of potash (high grade),	42.	-	-	1020.	-	-	-	-	-	866.	-	-	15.
Sulphate of potash-magnesia,	97.	-	-	496.	-	125.	51.	-	-	885.	-	52.	28.
Carbonate of potash,	538.	-	-	370.	-	-	-	390.	-	-	-*	-	8.
Phosphate of potash,	75.	-	-	651.	750.	-	-	-	-	269.	-	-	18.
Kainite,	64.	-	-	271.	-	379.	23.	196.	-	405.	-	665.	43.
Carnallite,	-	-	-	274.	-	153.	-	264.	-	11.	-	831.	-
Krugite,	96.	-	-	168.	-	105.	249.	176.	-	639.	-	133.	299.
Sulphate of magnesia (kieserite),	454.	-	-	-	-	-	56.	346.	-	722.	-	-	115.
Nitrate of potash,	26.	-	254.	905.	-	-	-	-	-	-	-	-	-
Nitrate of soda,	28.	-	300.	-	-	710.	-	-	-	-	-	10.	10.
Sulphate of ammonia,	212.	-	441.	-	-	-	-	-	-	1200.	-	-	-
Phosphate of ammonia,	120.	-	207.	-	877.	-	-	-	-	249.	-	-	16.
Sulphate of soda,	28.	-	-	-	-	-	-	-	-	1189.	-	-	-
Saltpetre waste,	51.	-	44.	273.2	-	740.8	15.	38.	-	37.	-	925.	-

Nitre salt-cake,	121.	-	56.	17.	-	591.	-	-	-	955.	-	-	78.
Wood ashes,	213.	-	-	107.	30.	-	712.	66.	19.	-	-	-	284.
Cotton-seed-hull ashes,	164.	-	-	455.	163.	-	186.	209.	35.	-	-	-	269.
Ashes of spent tan-bark,	97.	-	-	36.	37.	-	622.	68.	36.	-	-	-	504.
Corn-cob ashes,	24.	-	-	142.	47.	-	234.	-	26.	-	-	-	1042.
Railroad-tie ashes,	94.	-	-	18.	11.	-	50.	-	-	-	-	-	1604.
Peat ashes,	93.	-	-	9.	2.	-	46.	33.	123.	-	-	-	903.
Logwood ashes,	30.	-	-	2.	56.	-	78.	-	-	-	-	-	194.
Hard-pine wood ashes,	15.	-	-	203.	45.	-	499.	-	-	-	-	-	598.
Mill ashes,	11.	-	-	32.	9.	-	699.	27.	-	-	-	-	727.
Ashes from cremation of swill,	98.	-	-	93.	293.	-	672.	37.	.93	-	-	-	395.
Ashes from blue works,	243.	1276.	-	180.	-	-	-	-	-	-	-	-	246.
Seaweed ashes,	29.	-	-	18.	6.	175.	121.	87.	-	60.	-	132.	1273.
Gypse,	33.	-	-	-	-	-	1017.	-	-	-	-	-	57.
Nova Scotia plaster (gypsum),	173.	-	-	-	-	-	657.	15.	-	902.	-	-	69.
Onondaga plaster (New York gypsum),	265.	-	-	-	-	-	606.	93.	-	650.	164.	-	187.
Lime (burnt),	-	-	-	-	-	-	1973.	-	-	-	-	-	27.
Waste lime,	16.	-	-	-	-	-	1482.	-	-	-	-	-	8.
Gas-house lime,	446.	-	-	-	-	-	873.	166.	-	415.	-	-	121.
Lime waste from sugar factory,	726.	-	-	4.	45.	-	550.	-	-	-	-	-	6.
Lime-kiln ashes,	290.	-	-	26.	22.	-	851.	52.	-	-	355.	-	154.
Bituminous coal ashes,	144.	-	-	12.	9.	-	-	-	-	-	-	-	1370.

* Not determined.

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc. — Concluded.													
Marls (Massachusetts),	274.	-	-	5.	21.	-	810.	13.	14.	-	571.	-	69.
Marls (Virginia),	320.	-	-	10.	2.	-	145.	4.	-	13.	145.	-	1285.
Green sand marls (Virginia),	25.	-	-	23.	187.	-	516.	-	103.	-	-	-	826.
Olive earth (Virginia),	39.	-	-	5.	275.	-	383.	-	120.	-	-	-	1011.
Ammoniated marl,	66.	-	32.	-	208.	-	-	-	-	-	-	-	-
Marl (North Carolina),	30.	-	-	1.	11.	-	439.	12.	-	-	-	-	1004.
II. Guanos, Phosphates, etc.													
Peruvian guano,	296.	752.	157.	52.	305.	-	-	-	-	-	-	-	132.
Bat guano from Texas,	802.	365.	129.	26.	75.	-	-	-	-	-	-	-	40.
Bat guano from Florida,	313.	-	195.	25.	67.	-	-	-	-	-	-	-	387.
Rat guano from Florida,	206.	-	66.	137.	46.	-	-	-	-	-	-	-	23.
Cuban guano,	485.	-	33.	-	267.	-	-	-	-	-	-	-	63.
Caribbean guano (orchilla),	146.	-	-	-	535.	-	799.	66.	-	54.	-	-	25.
Mona Island guano,	266.	-	15.	-	438.	-	750.	-	-	-	-	-	49.

South Carolina rock phosphate,	29.	-	-	-	549.	-	837.	61.	96.	-	-	-	181.
South Carolina floats,	17.	-	-	-	468.	-	-	-	-	-	-	-	403.
Florida rock phosphate,	42.	-	-	-	523.	-	608.	-	151.	-	-	-	556.
Soft Florida phosphate,	97.	-	-	-	375.	-	274.	-	136.	-	-	-	418.
Navassa phosphate,	152.	-	-	-	685.	-	749.	-	205.	-	-	-	54.
Brockville phosphate,	50.	-	-	-	704.	-	-	-	-	-	-	-	129.
Phosphatic slag,	29.	-	-	-	470.	-	973.	68.	202.	-	-	-	188.
Odorless phosphate,	60.	-	-	8.	391.	-	1028.	-	-	-	50.	-	183.
Dissolved bone-black,	206.	950.	-	-	320.	-	-	-	-	-	-	-	80.
Bone-black,	92.	-	-	-	565.	-	-	-	-	-	-	-	73.
Double superphosphate,	115.	-	-	-	956.	-	320.	-	-	24.	-	-	12.
South American bone ash,	140.	-	-	-	718.	-	898.	-	-	-	-	-	90.
Acid phosphate,	285.	1399.	-	-	293.	-	-	-	-	-	-	-	216.
III. Refuse Substances.													
Dried blood,	239.	127.	210.	-	40.	-	-	-	-	-	-	-	-
Ammonite,	118.	-	227.	-	69.	-	-	-	-	-	-	-	28.
Oleomargarine refuse,	171.	288.	242.	-	18.	-	-	-	-	-	-	-	19.
Felt refuse,	585.	671.	105.	-	-	-	-	-	-	-	-	-	-
Sponge refuse,	145.	-	49.	-	64.	-	79.	25.	-	-	-	-	781.
Blood and bone,	167.	-	135.	-	220.	-	-	-	-	-	-	-	-
Horn shavings,	99.	-	306.	-	8.	-	-	-	-	-	-	-	-
Ivory dust,	230.	1053.	133.	-	491.	-	-	-	-	-	-	-	-

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Continued.													
Horn and hoof waste,	203.	153.	265.	-	37.	-	-	-	-	-	-	-	5.
Raw wool,	139.	151.	258.	-	-	-	-	-	-	-	-	-	72.
Wool waste,	235.	582.	91.	34.	6.	-	2.	1.	16.	-	-	-	164.
Wool washings (water),	-	-	-	78.	-	10.	6.	-	-	-	-	-	-
Wool washings (acid),	-	-	-	84.	-	8.	12.	4.	-	-	-	-	-
Wool washings (alkaline),	1841.	66.	2.	22.	-	18.	1.	-	-	-	-	-	4.
Morocco factory waste,	454.	-	23.	7.	51.	-	392.	-	-	25.	-	-	483.
Meat scrap,	496.	-	127.	-	116.	-	-	-	-	-	-	-	-
Meat mass,	242.	272.	209.	-	41.	-	-	-	-	-	-	-	12.
Bone soup,	1658.	141.	23.	-	25.	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	296.	168.	199.	-	11.	-	-	-	-	-	-	-	13.
Dried soup from rendering cattle feet,	216.	150.	289.	-	9.	-	-	-	-	-	-	-	5.
Dried soup from horse rendering,	1843.	-	22.	-	3.	-	-	-	-	-	-	-	-
Soap-grease refuse,	585.	1028.	64.	-	264.	-	-	-	-	-	-	-	26.
Bones,	137.	1061.	78.	-	447.	-	-	-	-	-	-	-	22.

Meat and bone,	105.	-	91.	-	404.	-	-	-	-	-	-	-	24.
Tankage,	191.	-	138.	-	230.	-	-	-	-	-	-	-	-
Fish with less than twenty per cent. water,	246.	430.	151.	-	170.	-	-	-	-	-	-	-	40.
Fish with between twenty and forty per cent. water,	604.	412.	119.	-	142.	-	-	-	-	-	-	-	34.
Fish with more than forty per cent. water,	909.	310.	99.	-	102.	-	-	-	-	-	-	-	27.
Whale meat, raw,	890.	21.	96.	-	-	-	-	-	-	-	-	-	-
Lobster shells,	145.	-	90.	-	70.	-	445.	26.	-	-	-	-	5.
Castor-bean pomace,	194.	114.	110.	31.	44.	-	17.	6.	-	-	-	-	35.
Cotton-seed meal,	136.	116.	135.	35.	33.	-	-	-	-	-	-	-	6.
Rotten brewers' grain,	1575.	-	15.	1.	17.	-	5.	3.	-	-	-	-	12.
Mill sweepings,	190.	-	75.	13.	24.	-	-	-	-	-	-	-	100.
Tobacco leaf,	261.	420.	55.	145.	9.	-	83.	43	6.	-	-	-	83.
Tobacco stems,	212.	281.	46.	141.	12.	7.	78.	25.	-	-	-	-	16.
Cotton waste, wet,	694.	-	26.	16.	31.	-	49.	23.	-	-	-	-	827.
Cotton waste, dry,	117.	1212.	35.	28.	9.	-	-	-	-	-	-	-	652.
Refuse from calico works,	81.	-	86.	-	239.	-	-	-	-	-	-	-	-
Cotton dust,	689.	1019.	10.	4.	4.	-	18.	18.	-	-	-	-	949.
Glucose refuse,	162.	-	52.	3.	6.	-	4.	.4	-	-	-	-	1.
Waste from lactate factory,	682.	-	14.	-	13.	-	452.	-	-	-	-	-	138.
Hop refuse,	180.	-	20.	2.	4.	-	5.	2.	-	-	-	-	13.
Banana skins,	280.	-	5.	109.	36.	-	-	-	-	-	-	-	-
Tankage and blood,	289.	-	118.	-	137.	-	-	-	-	-	-	-	-

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Concluded.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Concluded.													
Sumac waste,	1261.	136.	24.	65.	-	-	23.	65.	-	-	-	-	45.
Eel grass,	708.	312.	17.	18.	6.	33.	43.	2.	-	-	-	-	21.
Pine-barren grass,	170.	48.	3.	1.	4.	-	-	-	-	-	-	-	33.
Pine needles,	200.	68.	9.	1.	2.	-	-	-	-	-	-	-	24.
Rockweed, green,	1370.	474.	12.	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	214.	715.	29.	98.	55.	158.	153.	4.	-	-	-	-	208.
Jute waste,	262.	-	3.	2.	14.	-	-	-	-	-	-	-	-
Hair waste,	1456.	-	28.	6.	12.	-	-	-	-	-	-	-	-
Starch waste from rubber factory,	200.	5.	4.	-	-	-	-	-	-	-	-	-	-
Sludge from sewage precipitating tanks,	1770.	190.	1.	1.	2.	-	32.	8.	124.	-	-	-	19.
Sludge,	126.	-	14.	-	27.	-	173.	-	354.	-	-	-	761.
Residue from water filter,	1884.	-	2.	-	1.	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*), dry,	325.	-	85.	16.	4.	71.	41.	24.	-	-	-	-	111.
Mussel mud, wet,	1200.	546.	4.	123.	2.	14.	19.	3.	70.	-	-	-	-
Mussel mud, dry,	45.	1440.	14.	-	7.	-	1468.	165.	-	-	-	-	752.

Madder,	239.	-	18.	48.	7.	-	79.	10.	-	-	-	-	93.
Salt mud,	1567.	824.	8.	7.	-	19.	18.	7.	83.	-	-	-	798.
Fresh-water mud,	807.	-	27.	4.	5.	-	25.	6.	36.	-	-	-	365.
Muck,	1194.	275.	18.	-	3.	-	-	-	-	-	-	-	227.
Peat, wet,	1227.	153.	17.	4.	2.	-	11.	14.	43.	-	-	-	43.
Peat, dry,	293.	345.	38.	1.	1.	-	-	-	-	-	-	-	203.
Turf,	386.	127.	39.	-	-	-	-	-	-	-	-	-	-
Soot,	86.	1542.	8.	13.	23.	-	60.	24.	128.	-	-	-	1321.
IV. Animal Excrement, etc.													
Barn-yard manure,	1340.	-	10.	11.	8.	-	6.	4.	-	-	-	-	162.
Horse manure,	225.	-	15.	56.	29.	-	-	-	-	-	-	-	252.
Sheep manure,	1205.	-	23.	33.	13.	-	-	-	-	-	-	-	258.
Drainage from manure heap,	1864.	73.	20.	18.	5.	-	-	-	-	-	-	-	-
Poudrette, dry,	105.	709.	72.	10.	115.	-	-	-	-	-	-	-	93.
Goose manure,	978.	-	4.	16.	19.	-	-	-	-	-	-	-	-
Hen manure, fresh,	1047.	49.	20.	5.	15.	-	24.	18.	-	25.	-	-	470.
Hen-house refuse,	69.	-	20.	12.	26.	-	-	-	-	-	-	-	-

4. Compilation of Analyses of Fruits, Garden Crops and Insecticides.

COMPILED BY H. D. HASKINS.

1. — Analyses of fruits.
2. — Analyses of garden crops.
3. — Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops.
4. — Analyses of insecticides.

A computation of the results of a chemical analysis of twenty prominent garden crops shows the following average relative proportion of the three essential ingredients of plant food: —

	Parts.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain, on the above-stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weight and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limit pays, as a rule, better than a scanty one. — (C. A. Goessmann.)

1. *Analyses of Fruits.*

Fertilizing Constituents of Fruits.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Ericaceæ: —										
*Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
*Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
*Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
*Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
*Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–
*Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Saxifragaceæ: —										
*Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
*Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	–	–
Vitaceæ: —										
Grapes,	830	1.7	8.8	5.0	.1	1.0	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

2. *Analyses of Garden Crops.*

Fertilizing Constituents of Garden Crops.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ:—										
Mangolds,	880	1.8	9.1	4.8	1.5	.3	.4	.8	.3	.9
*Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–
Mangold leaves,	905	3.0	14.6	4.5	2.8	1.6	1.4	1.0	.8	2.3
Sugar beets,	805	1.6	7.1	3.8	.6	.4	.6	.9	.3	.3
*Sugar beets,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Sugar-beet tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Sugar-beet leaves,	897	3.0	15.3	4.0	2.0	3.1	1.7	.7	.8	1.3
Sugar-beet seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9
*Red beets,	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–
Spinach,	903	2.4	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
*Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositeæ:—										
Lettuce, common,	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Head lettuce,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	.4	.8
*Head lettuce,	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Roman lettuce,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4
Artichoke,	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
*Artichoke, Jerusalem,	775	4.6	–	4.8	–	–	–	1.7	–	–
Convolvulaceæ:—										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ:—										
White turnips,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
*White turnips,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
White turnip leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2
*Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Savoy cabbage,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
White cabbage,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
*White cabbage,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3

Fertilizing Constituents of Garden Crops — Continued.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Cruciferæ — Concluded.										
Radishes,	933	1.9	4.9	1.6	1.0	.7	.2	4.5	.3	.5
Kohlrabi,	850	4.8	12.3	4.3	.8	.4	.8	2.7	1.1	.6
Cucurbitaceæ: —										
Cucumbers,	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins,	900	1.1	4.4	.9	.9	.3	.2	.7	.3	.4
Gramineæ: —										
Corn, whole plant, green,	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5
*Corn, whole plant, green,	786	4.1	-	3.8	.5	1.5	.9	1.5	-	-
Corn kernels,	144	16.0	12.4	3.7	.1	.3	1.9	5.7	.1	.2
*Corn kernels,	100	18.2	-	4.0	.3	.3	2.1	7.0	-	-
*Corn, whole ears,	90	14.1	-	4.7	.6	.2	1.8	5.7	-	-
*Corn stover,	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	-	-
Leguminosæ: —										
Hay of peas, cut green,	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
*Cow-pea (*Dolichos*), green,	788	2.9	-	3.1	.6	3.0	1.0	1.0	-	-
*Small pea (*Lathyrus sylvestris*), dry.	90	38.5	-	25.7	4.7	17.9	5.0	9.0	-	-
Peas (seed),	143	35.8	23.4	10.1	.2	1.1	1.9	8.4	.8	.4
Pea straw,	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Garden beans (seed),	150	39.0	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Bean straw,	166	-	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
Liliaceæ: —										
Asparagus,	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
Onions,	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
*Onions,	892	-	4.9	1.8	.1	.4	.2	.7	-	-
Solanaceæ: —										
Potatoes,	750	3.4	9.5	5.8	.3	.3	.5	1.6	.6	.3
*Potatoes,	798	2.1	9.9	2.9	.1	.1	.2	.7	-	-
Potato tops, nearly ripe,	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe,	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
*Tomatoes,	940	1.7	-	3.6	-	.3	.2	.4	-	-
Tobacco leaves,	180	34.8	140.7	40.7	4.5	50.7	10.4	6.6	8.5	9.4
Tobacco stalks,	180	24.6	64.7	28.2	6.6	12.4	.5	9.2	2.2	2.4
*Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	-	-

Fertilizing Constituents of Garden Crops — Concluded.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Umbelliferæ: —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.5	.4
*Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	-	-
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	-	-
Parsnips,	793	5.4	10.0	.4	.2	1.1	.6	1.9	.5	.4
*Parsnips,	803	2.2	-	6.2	.1	.9	.5	1.9	-	-
Celery,	841	2.4	17.6	7.6	-	2.3	1.0	2.2	1.0	2.8

Most of the foregoing analyses were compiled from the tables of E. Wolff. Those marked * are from analyses made at the Massachusetts State Agricultural Experiment Station, Amherst, Mass.

3. *Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Ericaceæ: —			
*Cranberries,	1	3.0	–
*Cranberries,	1	3.4	2.6
Rosaceæ: —			
Apples,	1	2.7	2.0
*Apples,	1	1.9	1.3
*Peaches,	1	1.3	–
Pears,	1	3.6	1.2
Strawberries,	1	1.4	–
*Strawberries,	1	2.6	–
*Strawberry vines,	1	.7	–
Cherries,	1	3.3	–
Plums,	1	4.3	–
Saxifragaceæ: —			
*Currants, white,	1	2.8	–
*Currants, red,	1	2.1	–
Gooseberries,	1	1.9	–
Vitaceæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7

Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Chenopodiaceæ: —			
Mangolds,	1	6.0	2.3
*Mangolds,	1	4.2	2.1
Mangold leaves,	1	4.5	3.0
Sugar beets,	1	4.2	1.8
*Sugar beets,	1	4.8	2.2
Sugar-beet tops,	1	2.3	1.7
Sugar-beet leaves,	1	5.7	4.3
Sugar-beet seed,	1	1.5	–
*Red beets,	1	4.1	3.3
Spinach,	1	1.7	3.1
*Spinach,	1	19.2	6.8
Compositeæ: —			
Lettuce,	1	5.3	–
*Lettuce,	1	7.6	4.0
Head lettuce,	1	3.9	2.2
Roman lettuce,	1	2.3	1.8
*Jerusalem artichoke,	1	2.8	2.7
Convolvulaceæ: —			
Sweet potato,	1	4.6	3.0
Cruciferæ: —			
White turnips,	1	3.6	2.3
*White turnips,	1	3.9	1.8
White turnip leaves,	1	3.1	3.3
*Ruta-bagas,	1	4.1	1.6
Savoy cabbage,	1	1.9	2.5
White cabbage,	1	4.1	1.7
*White cabbage,	1	11.0	7.6
Cauliflower,	1	2.3	2.5
Horse-radish,	1	3.9	2.2
Radishes,	1	3.2	3.8
Kohlrabi,	1	1.6	1.8
Cucurbitaceæ: —			
Cucumbers,	1	2.0	1.3
Pumpkins,	1	.6	.7
Gramineæ: —			
Corn, whole plant, green,	1	3.7	1.9
*Corn, whole plant, green,	1	2.2	2.8
Corn kernels,	1	.6	2.8
*Corn kernels,	1	.6	2.6
*Corn, whole ears,	1	.8	2.5
*Corn stover,	1	4.4	3.7

Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Garden Crops — Concluded.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Leguminosæ: —			
Hay of peas, cut green,	1	3.4	3.4
*Cow-pea (*Dolichos*),	1	3.1	2.9
*Small pea (*Lathyrus sylvestris*),	1	3.4	4.2
Peas (seed),	1	1.2	4.3
Pea straw,	1	2.8	4.0
Garden beans (seed),	1	1.2	4.0
Bean straw,	1	3.3	–
Liliaceæ: —			
Asparagus,	1	1.3	3.6
Onions,	1	1.9	2.1
*Onions,	1	2.6	–
Solanaceæ: —			
Potatoes,	1	3.6	2.1
*Potatoes,	1	4.1	3.0
Potato tops, nearly ripe,	1	2.7	3.1
Potato tops, unripe,	1	3.7	5.3
*Tomatoes,	1	8.7	4.5
Tobacco leaves,	1	6.2	5.3
Tobacco stalks,	1	3.1	2.7
Tobacco stems,	1	10.7	3.8
Umbelliferæ: —			
Carrots,	1	2.7	2.0
*Carrots,	1	5.7	1.7
Carrot tops,	1	2.9	5.1
*Carrot tops, dry,	1	8.0	5.1
Parsnips,	1	3.8	2.8
*Parsnips,	1	3.3	1.2
Celery,	1	3.5	1.1

4. *Analyses of Insecticides.*

	Moisture.	Arsenious Oxide.	Copper Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Matter Insoluble in Hydrochloric Acid.
Paris green,	1.30	62.55	32.84	3.10	-	-	-	-	-	-	-	-	0.21
Paris green,	1.41	61.40	33.20	3.90	-	-	-	-	-	-	-	-	0.09
Paris green,	1.40	61.15	33.10	3.71	-	-	-	-	-	-	-	-	0.64
Paris green,	1.15	53.91	31.27	8.10	-	-	-	-	-	-	-	-	0.04
Paris green,	1.34	61.25	33.35	3.93	-	-	-	-	-	-	-	-	0.13
Paris green,	1.31	61.21	33.45	3.94	-	-	-	-	-	-	-	-	0.09
Paris green,	1.15	59.92	30.40	-	-	-	-	-	-	-	-	-	0.10
Paris green,	1.27	54.80	30.85	6.50	-	-	-	-	-	-	-	-	0.12
"Sulphatine,"	1.40	-	2.61	-	-	-	48.28	4.73	-	18.60	-	-	1.63
"Death to Rose Bugs,"	2.95	-	1.05	-	-	-	34.53	4.35	-	17.76	-	-	0.49
"Professor De Graff's Carpet Bug Destroyer,"	95.81	-	-	-	-	0.78	-	0.48	0.27	-	0.26	0.90	-
"Oriental Fertilizer and Bug Destroyer,"	87.14	2.38	-	-	-	-	-	.64	3.00	-	3.50	-	-
"Non-poisonous Potato Bug Destroyer,"	-	-	-	-	-	-	-	-	-	68.20	-	1.38	1.50
Tobacco liquor,	37.71	-	-	-	2.12	-	-	-	-	3.07	6.55	0.23	-
Tobacco liquor,	40.89	-	-	-	0.53	-	-	-	-	1.47	16.34	0.01	-
Tobacco liquor,	-	-	-	-	4.55	-	-	-	-	-	-	-	-
Tobacco liquor,	-	-	-	-	4.82	-	-	-	-	-	-	-	-
"Nicotinia,"	10.00	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	2.34
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	38.12
"Peroxide of Silicate,"	1.65	0.57	0.33	-	-	-	-	49.66	-	41.18	-	-	2.31

As a rule, in all preceding analyses the essential constituents are determined and stated; blanks do not imply the absence of the non-essentials.

INDEX.

PUBLIC DOCUMENT . . . . No. 33.

NINTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

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Mass Officials -

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated, under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, B.Sc.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
Leonard Metcalf, B.S.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Robert H. Smith, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, B.Sc.,	*Assistant Chemist* (foods and feeding).
Robert A. Cooley, B.Sc.,	*Assistant Entomologist.*
Joseph H. Putnam, B.Sc.,	*Assistant Horticulturist.*
Benjamin K. Jones, B.Sc.,	*Assistant in Foods and Feeding.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

BULLETINS ISSUED, 1887–97.

No. 1. Protection of peach buds; effect of girdling; jumping sumac beetle.

No. 2. Grape-vine leaf hoppers; ants; poisonous doses of insecticides, and treatment; report on standard varieties of fruit.

No. 3. Bovine tuberculosis.

No. 4. Steam heat *v.* hot water for heating greenhouses; evaporated sulphur as an insecticide; plant diseases.

No. 5. Buffalo carpet beetle; larder beetle; clothes moth.

No. 6. Steam *v.* hot water; fungous diseases of plants.

No. 7. Tests of small fruits and vegetables; girdling; protection of fruit trees from animals; Japanese millets and beans; the gypsy moth.

No. 8. Steam *v.* hot water; peach yellows; danger from the use of milk coming from tuberculous cows.

No. 9. Soil tests.

No. 10. Special fertilizers for greenhouse crops; report on small fruits.

No. 11. Strength of rennet; hay caps; potato rot; fungicides and insecticides for fruit.

No. 12. Bud moth; spittle insects; squash bug; pea and bean weevil; May beetle; curculio; onion maggot; cabbage butterfly; tent caterpillar; forest tent caterpillar; stalk borer; pyramidal grape-vine caterpillar; grape-berry moth; codling moth; cabbage-leaf miner; gartered plume moth.

No. 13. Directions for using fungicides and insecticides.

No. 14. Fertilizers for corn.

No. 15. Over-bench *v.* under-bench heating; special fertilizers for plants under glass; varieties of strawberries, blackberries, raspberries.

No. 16. Summary of results in electro-culture.

No. 17. Fungicides and insecticides; varieties of grapes and peaches; protection of peach buds; copper on sprayed fruit; Siberian crab as a stock; girdling grape vines; spraying apparatus.

No. 18. Fertilizers for potatoes, oats and corn; muriate of potash; corn and millet as grain crops; report on oats, hemp, flax, English wheats, Japanese millets and beans.

No. 19. Gypsy moth; effect of Paris green on foliage; Barnard's insect trap; lice and spiders on rose bushes; kerosene emulsion; effects of Paris green on tent caterpillars; cranberry insects.

No. 20. Canker worms; tent caterpillar; fall web worm; tussock moths.

No. 21. Bordeaux mixture; ammoniacal carbonate of ammonia; copper sulphate; fruits.

No. 22. Small fruits.

No. 23. Electro-culture.

No. 24. Arsenate of lead; Paris green and lime; Jamestown weed; horn fly.

No. 25. Fungicides and insecticides; grape tests.

No. 26. Strawberries; blackberries; raspberries.

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.

No. 28. Canker, army and corn worms; red-humped apple-tree caterpillar; antiopa butterfly; currant stem girdler; imported elm-bark louse; greenhouse orthezia.

No. 29. Fungicides and insecticides; new spraying pump; spraying calendar.

No. 30. Fertilizer analyses.

No. 31. Fertilizer analyses.

No. 32. Fertilizer analyses.

No. 33. Glossary of fodder terms.

No. 34. Fertilizer analyses; analyses of manurial substances.

No. 35. Agricultural value of bone meal.

No. 36. Imported elm-leaf beetle; maple pseudococcus; abbot sphinx; San José scale.

No. 37. Report on fruits, insecticides and fungicides.

No. 38. Fertilizer analyses; composition of Paris green; action of muriate of potash on the lime resources of the soil.

No. 39. Economic feeding of milch cows.

No. 40. Fertilizer analyses.

No. 41. On the use of tuberculin (translated from Dr. Bang).

No. 42. Fertilizer analyses; fertilizer laws.

No. 43. Effects of electricity on germination of seeds.

Special Bulletins.

Index, 1888 to 1895.
Gypsy moth.
The most profitable use of commercial fertilizers (translated from Paul Wagner).
The true value of green manuring (translated from Julius Kuehn).

Of the above bulletins, the edition of No. 2 is entirely exhausted; Nos. 1, 3–24 inclusive, 26, 30–32 inclusive and 34 are nearly exhausted, a few copies of each remaining, which can only be supplied to complete sets for libraries; Nos. 25, 27–29 inclusive, 33, 35–43 inclusive, and the index number are still in stock.

ANNUAL REPORT

Of George F. Mills, *Treasurer pro tem.*, of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1896.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,218 50	
for labor,	3,541 94	
for publications,	2,816 86	
for postage and stationery,	284 66	
for freight and express,	185 60	
for heat, light and water,	110 15	
for seeds, plants and sundry supplies,	572 98	
for fertilizers,	96 88	
for feeding stuffs,	291 51	
for library,	686 83	
for tools, implements and machinery,	326 63	
for furniture and fixtures,	70 47	
for scientific apparatus,	96 00	
for travelling expenses,	92 31	
for contingent expenses,	155 11	
for building and repairs,	453 57	
		$15,000 00
On hand July 1, 1895: —		
Received from Dr. Goessmann,	$1,704 37	
from State treasurer,	10,000 00	
from fertilizer fees,	3,627 17	
from farm products,	1,204 46	
from miscellaneous,	733 64	
		$17,269 64
Cash paid for salaries,	$9,502 66	
for labor,	434 02	
for publications,	115 37	
for postage and stationery,	186 64	
for freight and express,	127 77	
Amounts carried forward,	$10,366 46	$17,269 64

Amounts brought forward,	$10,366 46	$17,269 64
Cash paid for heat, light and water,	287 31	
for chemical supplies,	901 98	
for seeds, plants and sundry supplies,	475 34	
for fertilizers,	825 01	
for feeding stuffs,	484 58	
for library,	332 86	
for tools, implements and machinery,	15 15	
for furniture and fixtures,	311 98	
for scientific apparatus,	15 50	
for live stock,	365 00	
for travelling expenses,	17 19	
for contingent expenses,	491 66	
for building and repairs,	1,336 70	
Balance,	1,042 92	
		$17,269 64

AMHERST, MASS., Aug. 31, 1896.

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1896; that I have found the books well kept and the accounts correctly classified as above, and that the receipts for the year are shown to be $32,269.64 and the corresponding disbursements $31,226.72 All the proper vouchers are on file, and have been by me examined and found to be correct, there being a balance of $1,042.92 on accounts of the fiscal year ending June 30, 1896.

CHARLES A. GLEASON,
Auditor.

REPORT OF THE AGRICULTURIST.

WILLIAM P. BROOKS.

Leading Results and Conclusions based upon the Experiments outlined in the Report of the Agriculturist.

Cabbages and Swedes.

1. Soil-test work indicates that fertilizers for these crops should be particularly rich in available phosphoric acid and potash.

2. The muriate of potash has been found a useful form in which to supply the potash.

3. The material used to supply phosphoric acid in our experiment was dissolved bone-black, but it is believed that other available phosphoric acid fertilizers will be found equally serviceable.

Soy Beans.

1. Soil-test work shows a very intimate connection between potash supply and the growth of this crop.

2. The form in which potash has been supplied in soil tests is the muriate, but other experiments indicate that the sulphate is superior to this salt for beans.

Corn.

Soil Test with Corn. — A carefully conducted soil test with corn in Norwell, Plymouth County, upon somewhat exhausted soil, previously for many years in grass, shows potash to be here the controlling element for this crop, as in so many other places.

Hill v. Drill Culture of Corn. — Experiments continued in different fields from five to six years indicate that corn planted in drills will usually produce larger crops than when planted in hills. This increase is most marked, as might be expected, in case of the stover, but applies to the grain as well.

Green Manuring in Continuous Corn Culture.

1. *White mustard*, sown in standing corn at the time of the last cultivation, helps to keep down weeds, furnishes useful pasturage for sheep or young stock, conserves soil nitrogen, does not decrease the yield of corn the year it is sown, and can be counted upon to improve the soil if turned under. *It also helps largely to prevent soil washing in winter.*

2. *Crimson and sweet clovers* have not proved to be suited for green manuring crops in continuous corn culture, since they are not sufficiently hardy.

Variety Tests.

Potatoes.

1. Of 60 varieties of potatoes cultivated, but 5 showed themselves to be in any marked degree superior as crop producers to the Early Rose and Beauty of Hebron.

2. These, with rates of yield per acre in bushels, are as follows: Carman No. 1, merchantable, 355.3; small, 28.6. Fillbasket, merchantable, 336; small, 24.5. New Satisfaction, merchantable, 306; small, 25.7. Early Maine, merchantable, 305.1; small, 35.6. Dutton's Seedling, merchantable, 304.5; small, 19.8.

3. The Early Rose yielded: merchantable, 292.8; small, 21 bushels. The Beauty of Hebron (somewhat injured by proximity to other crops), merchantable, 275.9; small, 18.7 bushels.

4. The varieties tested showed no very marked differences in respect to ability to resist blight.

Corn.

1. Of 21 varieties of Flint corn cultivated, 7, or $33\frac{1}{3}$ per cent., gave a yield at the rate of $83\frac{1}{3}$ bushels per acre or over.

2. Of 46 varieties of Dent corn, 13, or 28 per cent., equalled or exceeded the same rate of production.

3. Among the best of the Flint varieties are the White Flint,* Sanford,* Compton's Early, Giant Long White and Longfellow.

4. Among the best Dent varieties as indicated by our trial are Yellow Rose, Mastodon, Reed's Yellow Dent, New Golden Triumph and Leaming; but Sibley's Pride of the North, though standing ninth in weight of ears produced, matured among the earliest, and is undoubtedly one of the best Dent varieties for grain production.

Clovers.

1. Crimson clover can be grown as an annual, and gives one good crop; but it will not usually survive our winters, and does not, therefore, at present appear to be worthy of attention as a fodder crop.

2. The mammoth clover exceeds the common red in productive capacity, having produced more hay in two cuttings than the common red in three. It is especially to be commended for sowing with timothy.

3. Alsike clover appears not to be as long lived as the mammoth and the common red.

Millets.

1. For seed production the Japanese "barn-yard" and the Japanese "common" again show their superiority, producing respectively 57 and 53.3 bushels per acre.

2. As a result of a careful comparison of 17 varieties, the Japanese white-seeded panicle millet and the Japanese barn-yard millet are found to lead all other varieties in productive capacity.

* These two are apparently nearly or quite identical.

New Crops.

The flat pea (*Lathyrus sylvestris*) has not been found to be of value as a fodder crop.

The horse bean (*Vicia faba*) has not been found to do well.

Sorghum of different varieties appears inferior to Indian corn as a fodder crop.

Saccaline is found not to be hardy and will probably not prove of value as a fodder crop.

Miscellaneous.

Fungiroid has not been found effective in preventing potato blight.

Sulphur applied in the drill did not prevent scab of potatoes.

The Symmes' hay cap is preferred to cloth caps.

Soil Tests.

Soil tests, upon the plan outlined in previous reports, have been carried on upon a somewhat less extensive scale. We have had four such experiments this year: one with soy beans and one with turnips and cabbages upon our own grounds; and one in Montague and another in Norwell with corn. Circumstances compelled the cessation of the work in Concord, Worcester and Shelburne, and it was not considered important to continue it longer in Hadley, as this town lies so near Amherst, and as the soil upon which we were working gave results so entirely similar to those obtained upon our own. The main conclusions justified by the results of the past season are as follows: —

1. Potash is the controlling element in the case of the corn crop in Norwell.

2. Nitrogen appears to have been the most useful element for the corn crop in Montague; but the results are obscured in a measure by differences in natural fertility in different parts of the field.

3. A combination of potash and phosphoric acid appears to be necessary to materially increase either the cabbage or the turnip crops in Amherst.

4. Potash proves much the most useful single element for the soy-bean crop in Amherst.

1. *Soil Tests with Corn.*

In Montague the experiment was carried out upon land belonging to Mr. H. M. Lyman, and is the first year this land has been used in such work. The field selected is level, and it was thought it would be suited for the purpose, though it had been more recently manured than we would have liked. The results show that it was not as even in fertility as is desirable. The yields of the five scattered nothing plats were respectively at the rates of 12, 10.5, 19, 32 and 19.9 bushels per acre. Under such conditions, we are not justified in attempting to draw general conclusions. The nitrate of soda appears to have produced an average increase at the rate of: grain, 11 bushels; stover, 158.5 pounds per acre. The average effect of the phosphate appears to have been a decrease in both grain and stover, while the potash appears to have increased the stover slightly but not the grain.

In Norwell the experiment was carried out upon land belonging to the writer, and is the first year this land has been used in such work. The field was in grass in 1895, and is in rather a low state of fertility. Throughout the season potash seemed to be the controlling element. At the time of harvesting, plat 5, receiving muriate of potash alone at the rate of 160 pounds per acre, appeared to be as heavy as either plats 10 or 13, receiving respectively complete fertilizer and stable manure. Owing to a slight accident at the time of harvesting, figures cannot be published at this time.

2. *Soil Test with Cabbages.*

This test occupied one-half of the land which has been designated the "north acre" in previous reports, the other half being occupied with Swedish turnips. The acre was

divided by a line running through the middle across the plats, the one end being devoted to cabbages, the other to turnips.

This acre had been for five years devoted to soil-test work, the crops in order of succession having been corn, potatoes, soy beans, grass and clover, and grass and clover. During this time the nothing plats have received no manure or fertilizer of any kind. The variety of cabbages raised was Fottler's Drumhead. The seed was planted in the field. The average yield of the nothing plats was at the rate of 2,470 pounds of hard and 7,190 pounds of soft cabbages per acre.

The average result of the application of phosphoric acid was an increase at the rate per acre: hard heads, 9,557.5 pounds; soft heads, 1,912.5 pounds, — a profit from the use of phosphate amounting to $23.08 per acre. The use of the phosphate without potash, however, had practically no effect upon the crop.

The average increase apparently due to the potash is at the rate per acre: hard heads, 10,147.5 pounds; while there is an average decrease in soft heads at the rate of 527.5 pounds per acre. The net average result of the use of potash is profit at the rate of $21.51 per acre. The potash, even without the phosphoric acid, produces a considerable increase, but produces two and one-half times as great an increase in combination with a phosphate.

The nitrogen is much less useful. The average is at the rate of 2,627.5 pounds increase in hard heads and 402.5 pounds decrease in soft heads, per acre. It produces the largest increase when used with phosphate. The net result of the use of nitrate of soda is a gain at the rate of $6.07 per acre.

The results are not as clear in their indications as could be wished, though they point to a close dependence of this crop upon both potash and phosphoric acid manuring. The experiment will be repeated when opportunity offers.

3. *Soil Test with Swedish Turnips.*

This crop, as stated above, occupied one-half of the acre on which the test with cabbages was carried out. The variety was Laing's Swedish turnip, sown June 13. The results show a close agreement with those obtained with the cabbages. The average of the nothing plats was at the rate of 10,250 pounds per acre.

The average result of the use of phosphoric acid (dis-solved bone-black) was an increase at the rate of 6,308.5 pounds per acre. Similar averages for the potash (muri-ate) and nitrogen (nitrate of soda) were, respectively, 7,255 and 2,891.7 pounds. The net average profits are at the rates per acre: for the phosphoric acid, $9.42; for the pot-ash, $11.35; and for the nitrate, $2.58.

Here, as with the cabbages, the combination of phosphoric acid and potash seems essential to large increase in the crop. The phosphoric acid without potash gives no increase; with potash alone, an increase at the rate of 11,700 pounds per acre. The potash alone gives an increase of but 400 pounds per acre, but with the phosphate it gives an increase of 13,633 pounds per acre.

The combination of phosphate and potash gives an in-crease at the rate of 12,100 pounds per acre, as compared with the nothing plats nearest to the one on which it was used.

4. *Soil Test with Soy Beans, Amherst, South Acre.*

This is the eighth season of soil-test work upon this acre. The beans, variety Medium Green, were sown May 19, in drills $2\frac{1}{2}$ feet apart, requiring 25 pounds seed for the acre. The nothing plats produced an average of 350 pounds beans and $757\frac{1}{2}$ pounds straw per acre.

Potash (muriate) appears to be the most useful element, giving an average increase per acre of $646\frac{2}{3}$ pounds beans and $51\frac{2}{3}$ pounds straw. The average increase per acre caused by phosphoric acid (dissolved bone-black) was $126\frac{2}{3}$ pounds beans and 250 pounds straw. Similar average for nitrogen (nitrate of soda) was $13\frac{1}{2}$ pounds beans and $116\frac{2}{3}$ pounds

straw. Nitrogen produced a decrease, except when used with both phosphoric acid and potash.

In appearance the beans grown upon potash were larger and plumper than those grown upon either phosphoric acid or nitrogen.

Manuring the Corn Crop.

1. *Manure alone v. Manure and Potash.*

The past is the sixth year of continuous culture of corn upon the same acre of land for the purpose of testing the relative value of an application yearly of a small quantity of *manure* with *muriate of potash*, as compared with a larger application of *manure alone*. When manure alone was applied, it was put on at the rate of 6 cords per acre, being spread broadcast after ploughing, and harrowed in. The manure and potash similarly applied have been put on at the rate of 4 cords of the former and 160 pounds of muriate of potash for the latter.

The plats, four in number, contain one-quarter of an acre each. The results are shown below : —

Plat 1, manure, 8,115 pounds: stover, 1,600 pounds; ear corn, 1,530 pounds.

Plat 2, manure, 5,354 pounds; muriate of potash, 40 pounds: stover, 1,300 pounds; ear corn, 1,455 pounds.

Plat 3, manure, 8,981 pounds: stover, 1,255 pounds; ear corn, 1,450 pounds.

Plat 4, manure, 5,711 pounds; muriate of potash, 40 pounds: stover, 970 pounds; ear corn, 1,120 pounds.

In plats 3 and 4 the corn was planted in hills, while in 1 and 2 it was planted in drills. This no doubt accounts in a measure for the considerable difference in yield. The inferiority of the crop from plat 4 is due to the fact that, from force of circumstances, poorer manure was used upon it in 1895 than upon the other plats.

Averaging the results upon 1 and 3 and upon 2 and 4, we find the yields have been at the following rates per acre : —

With manure alone : stover, 5,710 pounds ; grain, 73¼ bushels.

With manure and potash : stover, 4,540 pounds ; grain, 64⅝ bushels.

In no one of the six years during which this experiment has been continued has the crop raised on the combination of manure with potash equalled that raised on a larger quantity of manure alone; but the differences have been small, and in no case has the value of the excess in crop produced by the larger quantity of manure been sufficient to cover the excess in cost of the manure applied. The difference in crop is this year considerably larger than in any preceding year; and, as this difference has been quite steadily increasing, we are justified in concluding that the manure and potash in the quantities employed cannot fully take the place of the larger application of manure in continuous corn culture. It is true the crop where the manure and potash are employed is still an excellent one, averaging for the two plats at the rate of more than 63 bushels per acre. Continuous corn culture is not, however, the rule, nor indeed under most circumstances advisable, though often proved to be possible, at least for many years; and therefore this land has now been seeded to grass and clover, for the purpose of determining to what extent, if any, the introduction of these crops will enable the farmer under the given manuring to secure equal crops with both systems.

2. Special Corn Fertilizer v. Fertilizer containing More Potash.

This experiment in continuous corn culture was begun in 1891, and the present is, therefore, the sixth season. The object in view is a comparison of the results obtained with a fertilizer proportioned like the average of the "*special*" *corn fertilizers* found upon our markets in 1891 with those obtained with a fertilizer richer in potash but furnishing less nitrogen and phosphoric acid. The results in previous years have indicated the financial advantage to lie with the latter fertilizer.

Four plats of one-fourth of an acre each are devoted to this experiment, which are respectively numbered 1, 2, 3 and 4.

The materials applied to the several plats are shown below: —

FERTILIZERS.	Plats 1 and 3 (Pounds Each).	Plats 2 and 4 (Pounds Each).
Nitrate of soda,	20	18
Dried blood,	30	30
Dry ground fish,	30	20
Plain superphosphate,	226	120
Muriate of potash,	22.5	60
Cost of materials per plat,	$3 23	$3 10

The materials supplied to plats 1 and 3 would furnish per acre the quantities of nitrogen, phosphoric acid and potash found in 1,200 pounds of fertilizer having the average composition of the "special" corn fertilizers upon the market at the time the experiment was commenced, viz., 1891. The average price per plat for 300 pounds of such fertilizer (the amount needed per plat to equal the above materials) is about $5.25.

The yields the past year are shown below: —

Plat 1, "special" fertilizer: stover, 935 pounds; ear corn, 1,110 pounds.

Plat 2, fertilizer richer in potash: stover, 995 pounds; ear corn, 1,030 pounds.

Plat 3, "special" fertilizer: stover, 790 pounds; ear corn, 1,135 pounds.

Plat 4, fertilizer richer in potash: stover, 865 pounds; ear corn, 1,065 pounds.

Computed to the acre and the grain in bushels, the averages are: "special," stover, 3,450 pounds; grain, 56.1 bushels; fertilizer richer in potash, stover, 3,720 pounds; grain, 52.4 bushels. It will be noticed that the "special" fertilizer gives rather more grain and less stover than the fertilizer richer in potash. This result is in entire accord with the results of previous years, and the indications are strong, therefore, that our mixture "richer in potash" needs modification to make it equal in grain-producing power to the "special" fertilizer for *continuous corn culture*. It is

still my belief, however, that under ordinary farm conditions the "*fertilizer richer in potash*" would be found equal at least to the "special," for under such conditions grass and clover would alternate with the corn; the clover, judging from facts almost universally noticed, would thrive better where more potash had been used, and as a result the soil would be enriched in nitrogen, which would be favorable to the development of the succeeding corn crop. In all of our "soil-test" work the nitrogen has ranked next to the potash in benefit to this crop. With a view to testing the correctness of this conclusion, the land used for this experiment has now been seeded to grass and clover, and after two or three years will again be planted with corn.

The average crop raised on the "special" fertilizer this year is worth $0.83 more per acre than the average for the fertilizer richer in potash; the fertilizer materials used cost $0.52 more. There is no material difference, therefore, in the financial outcome of the two systems under the given conditions; but, as above pointed out, should the farmer purchase a manufactured "*special*" *corn fertilizer*, it would have cost him about $5.25 per plat, or $21 per acre, to procure equal amounts of the essential elements of plant food. Since the "*fertilizer richer in potash*" cost $3.10 per plat, or $12.40 per acre, while the crop was practically almost as valuable as that produced on the "special," it follows that here is a possible saving of almost $8 per acre in initial expenditure. It is true that the materials recommended require mixing, while the "special" fertilizer is already mixed. It is not true that the elements of plant food in the "special" are in better forms, or more available. In conclusion, however, it is but fair to state that the prices used in calculating the cost of the "*materials*" are cash prices, while the price of the "special" is determined in a measure by the fact that credit must often be given for such goods.

Hill v. Drill Culture for Corn.

In each of the two experiments above described one-half of each acre has each year been planted in drills and the other half in hills. Plats 1 and 2 in each case have been

planted in drills, and plats 3 and 4 in hills. The distance between the rows under both systems has been $3\frac{1}{2}$ feet. Under the "drill" system, the plants have been thinned to 1 foot; under the "hill" system, the hills are 3 feet apart and the plants are thinned to three in a hill. We thus have equal numbers of plants under the two systems. The results the past year average as follows: for the acre receiving manure, drill culture, at rate per acre, stover, 5,800 pounds; grain, $74\frac{5}{8}$ bushels; hill culture, at rate per acre, stover, 4,450 pounds; grain, 63 bushels; for the acre receiving fertilizer similar averages are, drill culture, stover, 3,630 pounds; grain, $53\frac{7}{8}$ bushels; hill culture, stover, 3,540 pounds; grain, $54\frac{5}{8}$ bushels. Averaging both experiments, we have, for drill culture, stover, 4,715 pounds; grain, $64\frac{1}{4}$ bushels; for hill culture, stover, 3,995 pounds; grain, $58.\frac{4}{5}$ bushels.

Green Manuring in Continuous Corn Culture.

White mustard as a crop for green manuring and nitrogen conservation was sown on one-half the acre where *manure alone* has been under comparison with *manure and potash* in each of the years from 1892 to 1894 inclusive, the seed being scattered in the standing corn late in July in each year. The growth varied greatly from year to year, but the practice proved beneficial. In 1895 the increase in the corn crop apparently due to the culture of the mustard amounted to: stover, 452 pounds; grain, 5.4 bushels. In July, 1895, the mustard was sown only on one-quarter of the acre, and, because of a very dry and hot autumn, the growth was light. The crop on this quarter this year shows an increase as compared with the quarter not so treated of: stover, 680 pounds; grain, 3 bushels, per acre.

The other plat, which had been sown with mustard in preceding years, was in 1895 sown with rye on September 5, at the rate of 3 bushels per acre. The growth was good, and the rye, when ploughed in on May 11, was 18 inches tall. The apparent result of this treatment is a decrease in crop at the rate per acre: stover, 700 pounds; grain, $4\frac{3}{4}$ bushels. It seems impossible to believe that the effect of this treatment can be permanently injurious. The decrease

in yield this year may be due to the fact that considerable available plant food which was locked up in the rye has not yet by the decay of the vegetable matter of this crop become again available. If this be the true explanation, then in the next year the beneficial effect of the green manuring should become apparent.

On the acre where "*special*" *corn fertilizer* has been under comparison with *fertilizer richer in potash* some crop of *the clover family* has been sown in the standing corn each year since 1893; but the crops themselves have been under trial, and have not shown themselves fitted for the purpose in view. Thus, in 1893 and 1894 *crimson clover* was tried, but each following spring the crop was killed and the results were unimportant. In July, 1895, *sweet clover* (*Melilotus alba*) was sown upon one quarter and common *red clover* upon another. The *sweet clover* was badly thrown out by the frost, and hardly a plant survived; while the red clover starts too late in spring to have made much growth before it must be turned in. The results are unimportant in both cases, though the crop this year is somewhat greater where the red clover was sown, viz., at the rate of 55.25 bushels per acre, against 52.75 bushels where no clover was sown.

Variety Tests.

1. *Potatoes.*

In the spring of 1895 we procured as far as possible seed of all prominent and new varieties of potatoes, necessarily from widely scattered and very different sources. This seed was planted for the purpose of raising under like conditions a stock of the different sorts, which, having been produced under identical conditions and in every respect handled alike, it was thought would be suited for a comparative test of varieties. Sixty varieties, the seed of which (in every instance save one) was raised upon our own grounds last season, have been made the subject of such a comparative trial this year. The variety the seed of which was from another source is Carman No. 1. Our seed of this sort raised last year was accidentally destroyed, and, as the variety is a prominent one, it was thought best to pro-

cure enough for this trial from a prominent grower in this State, Dr. Jabez Fisher of Fitchburg. Of most varieties we planted 2 rows, each 209 feet long; but in some cases, where the seed was insufficient, only 1 row was planted.

The seed was washed and treated with a solution (2 ounces to 15 gallons of water) of corrosive sublimate on April 13. The tubers were then placed on the earth in a cold frame without glass, where they were allowed to remain until May 1, when they were cut into pieces having two eyes each, and of as nearly equal size as possible. At this time the tubers had sent out numerous thick green sprouts, which were perhaps about one-eighth to one-fourth of an inch in length. The tubers when cut were rolled in plaster. They were planted on May 5 and 6, the pieces being placed just 1 foot apart in the rows. In those cases where the supply of seed was insufficient to plant a full row, the row was filled out with seed of the Beauty of Hebron, that there might be no vacancies.

The treatment of the seed with corrosive sublimate solution entirely prevented scab, and the system followed in sprouting the tubers was eminently satisfactory. It should perhaps be stated that when the sun shone hot the tubers were covered with a sheet of thin white cotton cloth. But for this protection it is to be feared that in a cold frame they might get overheated on excessively hot days.

The land where the test was made was last year in millet and soy beans, the rows this year running across the divisions of last season, so that each row of this year is exactly comparable with every other. The soil is a medium loam, well adapted to the potato. Fertilizers only were applied, and at the following rates per acre: nitrate of soda, 240 pounds; dried blood, 100 pounds; tankage, 240 pounds; plain superphosphate, 400 pounds, and high-grade sulphate of potash, 250 pounds. These materials were mixed and strewn in the furrows before the seed was dropped. All needful operations were seasonably and thoroughly carried out. The season was on the whole favorable, so that the crop suffered from no unusual conditions. Careful notes were taken throughout the season, covering all peculiarities in growth and development, time

of blossoming, etc. All varieties suffered somewhat from early blight (*Macrosporium solani*). This was first discovered on 1 variety on July 18. By the 22d it could be detected on 26 other varieties, and by August 3 all except 1 were affected. As early as August 8 the vines of 17 varieties were entirely dead. Between the 8th and 20th the vines of 26 other varieties died, while by August 29 all were dead.

An attempt to prevent this blight by repeated applications of "Fungiroid" was an entire failure. It will be noticed that considerable differences in degree of susceptibility to "blight" showed themselves. Until the varieties have been further tested, however, it is not deemed advisable to publish the details.

The crop was harvested in part on September 10–12, and the balance September 24–25. There was no rot, and the tubers were for the most part smooth and handsome.

The yield has been in every case corrected to 207 hills or sets, so that the results are strictly comparable. The area occupied by this number of hills is almost exactly one-seventieth part of an acre; so that, to bring out the significance of the differences more clearly, I have multiplied the results by seventy, and converted into bushels, thus showing the *rate per acre* yielded by the different sorts.

The varieties are reported in alphabetical order, and for each the tubers are divided into the customary classes, viz., merchantable and small.

Varieties of Potatoes, Yield per Acre (Bushels).

NAME.	Merchantable Tubers.	Small Tubers.
Alexander's Prolific,	123.3	14.0
Alliance,	285.8	42.0
Beauty of Hebron,	275.9	18.7
Bill Nye,	226.3	25.7
Bliss's Triumph,	276.5	25.7
Burbank's Seedling,	207.7	23.3
Burpee's Extra Early,	208.8	49.0
Carman No. 1,	355.3	28.6
Carman No. 3,	199.5	16.9
Chance,	201.8	30.3

Varieties of Potatoes, Yield per Acre (Bushels) — Concluded.

NAME.	Merchantable Tubers.	Small Tubers.
Clarke No. 1,	255.5	26.8
Columbus,	265.4	33.3
Crown Jewel,	169.1	29.2
Dakota Red,	283.5	28.0
Delaware,	235.7	22.2
Dutton's Seedling,	304.5	19.8
Early Essex,	162.2	35.0
Early Harvest,	234.5	44.3
Early Maine,	305.1	35.6
Early Market,	229.9	28.6
Early May,	232.8	22.2
Early Northern,	266.0	42.0
Early Ohio,	159.8	17.5
Early Ohio, Jr.,	232.8	25.1
Early Rose,	292.8	21.0
Early Sunrise,	268.3	32.7
Empire State,	271.3	12.3
Fillbasket,	336.0	24.5
Freeman's,	203.6	30.9
Hampden Beauty,	232.8	27.4
Hampden Chief,	187.8	4.7
Henderson's Early Puritan,	250.8	34.4
Irish Daisy,	172.1	59.1
Late Puritan,	277.1	28.0
Maggie Murphy,	227.5	28.0
Merriman,	266.6	44.9
Monroe Co. Prize,	240.3	31.5
Monroe Co. Seedling,	248.5	21.0
New Ideal,	204.2	8.2
New Queen,	255.5	49.2
New Satisfaction,	306.8	25.7
Onward,	200.7	26.3
Polaris,	149.3	31.5
Pride of the West,	243.8	26.8
Quick Return,	239.8	29.8
Restaurant,	259.0	21.6
Rochester Rose,	272.4	31.5
Rural New Yorker No. 2,	218.8	22.2
Sir William,	282.9	19.8
Six Weeks,	141.8	20.4
Snow Flake,	169.8	32.1
State of Maine,	252.6	34.4
Summit,	246.8	28.6
Sunlit Star,	232.8	41.4
Thorburn,	255.5	31.5
Vanguard,	255.5	30.9
White Elephant,	295.8	23.9
White Star,	235.1	28.0
Woodbury's White,	289.3	26.3
World's Fair,	145.8	26.8

A study of these figures reveals the fact that there are wide differences in yield; but it is noteworthy that the yield of such old standard sorts as the Early Rose and Beauty of Hebron stands far above the average. The yield of the Early Rose is exceeded by but 6 varieties, viz., Carman No. 1, Fillbasket, New Satisfaction, Early Maine, Dutton's Seedling and White Elephant, named in the order of superiority. In addition to these, 6 other varieties, viz., Woodbury's White, Alliance, Dakota Red, Sir William, Late Puritan and Bliss's Triumph slightly exceed the yield of the Beauty of Hebron. In justice to this variety, it is proper to state that it occupied an outside row adjoining land planted to millet, rape and mustard, and was undoubtedly somewhat injured by its proximity to these, as their growth was exceptionally rank. It may well be doubted whether, under precisely equal conditions, the Beauty of Hebron would have been exceeded in yield by a larger number of varieties than was the Early Rose.

The varieties especially noteworthy for large yield in the order of actual production of merchantable tubers, then, with rates per acre in bushels, are the following: Carman No. 1, 355.3; Fillbasket, 336; New Satisfaction, 306.8; Early Maine, 305.1; Dutton's Seedling, 304.5; White Elephant, 295.8; Early Rose, 292.8; Woodbury's White, 289.3; Alliance, 285.8; Dakota Red, 283.5; Sir William, 282.9; Late Puritan, 277.1; Bliss's Triumph, 276.5; and Beauty of Hebron, 275.9. These varieties will all be tested as to eating and keeping qualities.

Seed of 21 other varieties has this season been procured in small amounts from various sources, and the tubers produced from these will be preserved for comparison another season. Ten of these have given a yield at the rate of more than 300 bushels of merchantable tubers per acre, and are therefore very promising.

2. Corn.

Sixty-seven varieties of field corn have been under trial upon a small scale, for the purpose of preliminary observations as to merits and adaptability to different uses; 21 of these were Flint and 46 Dent varieties. Three rows (each

75 feet long) of each variety, with one or two exceptions where not sufficient seed could be obtained, were planted. The trial has involved a large expenditure of time and attention. Notes have been taken from day to day, covering such points as germination, dates of tasselling and silking, height, relative leafiness, time of cutting, etc. The autumn was exceptionally unfavorable to curing of the corn crop; and hence, though an exact record of the weights of product (sound hard ears, soft ears and stover) has been made, it is of less value as a basis for comparative judgment than would ordinarily be the case. Particularly is this true in relation to the stover of the later Dent varieties.

The field used for this trial was in corn last year. The soil is a medium heavy loam, and quite even in quality throughout. *A fertilizer supplying, per acre, nitrate of soda, 72 pounds; dried blood, 120 pounds; dry ground fish, 80 pounds; plain superphosphates, 480 pounds; and muriate of potash, 240 pounds, was applied broadcast after ploughing, and harrowed in.* The rows were uniformly spaced throughout the field, viz., 3½ feet apart. The corn was so planted in checks that when thinned it stood, single plants, at the following intervals in the row: *for all Flint varieties*, 8 inches; for the earlier Dents, 10 inches; and for the later Dents, 12 inches.

Without going into much detail, I have to report further concerning this trial: —

1. That the following pairs of varieties appear to be nearly if not quite identical: —

Champion White Pearl and White Pearl.
Buckbee's No. 7 and Colossal.
White Cap Dent and White Cap Yellow Dent.
Sanford and White Flint.
Rideout and Longfellow.
Dibble's Early Mammoth and Houghton's Silver White Flint.

2. The yield of ear corn all or nearly all of which was sound and well cured varied: for the Flint varieties, between 79 and 130 pounds; for the Dent varieties, between 78 and 144 pounds.

3. Seven out of the 21 Flints gave a yield of 120 pounds* or over; 13 of the 46 Dents gave a similar yield, but with a larger proportion of imperfectly cured ears; 33 per cent. of the Flints and 28 per cent. of the Dents, therefore, come into this class.

4. The yield of stover varied: for the Flint corns, between 104 and 245 pounds; for the Dent corns, between 94 and 451 pounds. Some of the Dents giving high yields of stover were far from perfectly cured.

5. The order of rank in yield of ears of the best 5 Flint varieties was as follows: White Flint, Sanford, Compton's Early, Giant Long White and Longfellow.

6. The best 5 Dent varieties in order of ear production are: Yellow Rose, Mastodon, Reed's Yellow Dent, New Golden Triumph and Leaming.

7. Sibley's Pride of the North, very thoroughly matured, ranks ninth in production of ears, and is undoubtedly one of the best Dent varieties for grain production.

8. The following varieties appear to be unsuited to our locality, on account of being too late: Brazilian, Farmer's Favorite, Queen of the Prairie, Golden Beauty, Golden Dent, Legal Tender, Mammoth White Surprise and Dr. Woodhull.

9. Three other varieties are certainly too late for culture as grain crops, but appear to promise well for the silo, viz., New Golden Triumph, Hickory King and Mastodon.

3. *Clovers.*

Four varieties of clover have been given a thorough comparative trial, viz., mammoth (*Trifolium medium*), common red (*T. pratense*), alsike (*T. hybridum*) and crimson (*T. incarnatum*). The soil of Field B is a medium heavy loam, but thoroughly drained. For some twelve years it has been manured only with ground steamed bone and potash salts. The plats are one-tenth of an acre each in size. Every plat is manured yearly with ground bone, at the rate of 600 pounds to the acre; one-half of these plats receive yearly an

* A yield of 120 pounds corresponds to a product of 83⅓ bushels shelled grain per acre.

application of muriate of potash at the rate of 200 pounds per acre, and the other half receive the same quantity of high-grade sulphate of potash. The land was occupied by grain crops cut for fodder in 1895. Soon after the fodder was removed the land was ploughed, and the seed was sown on August 1. Of the mammoth and common red clovers, 3 pounds of seed per plat were sown; of the alsike clover, $2\frac{1}{2}$ pounds; and of the crimson clover, 4 pounds. The seed of all varieties started promptly and well and all varieties went into the winter in excellent condition.

The crimson clover early in March appeared to be in good condition, but during the latter weeks of March it gradually weakened and died. By the first of April there was scarcely a plant in the field alive. This species appears unable to endure our average spring weather. The crimson clover plats were accordingly ploughed in April and resown, $5\frac{1}{2}$ pounds of seed per plat being used, on April 24. The seed started quickly, and, as will be seen by the tables which follow, this variety gave one good crop, at the rate of nearly 3 tons to the acre on the best plat. This clover was cut on July 17, at which time it was in *mid-bloom*. Notwithstanding frequent showers soon after, the stubble failed to start, and in a few weeks was almost entirely dead, at which time the plats were reploughed. It will undoubtedly be found necessary to cut this variety just as it begins to bloom, in order to insure later cuttings.

The very few plants in this field (as well as those from another with lighter soil) which survived the early spring weather were taken up and replanted, in order to secure seed, in the hope that we may in time by a continuance of this process of selection produce a strain or variety of this species which will prove hardy with us.

For culture as an annual it seems unlikely that crimson clover will prove of much importance, as in that case it would not give earlier fodder than the other clovers. Could it be cultivated as a winter annual, on the contrary, it must take an important place as a crop both for fodder and for green manuring, — for fodder chiefly, because it would be ready to cut at so early a date, and for green manuring, since it grows so rapidly.

Mammoth Clover. — This variety was cut on June 23, at which time it was not in full bloom. It was thought best to harvest, as it was lodging badly. On August 10 it was cut for the second time. It did not make sufficient growth thereafter to warrant cutting again. Though cut, therefore, but twice, while the common red clover was cut three times, the mammoth clover produced slightly more hay than the former. The two crops make a yield at the rate of rather more than 4½ tons per acre. This hay is not objectionably coarse, or, rather, not much more so than that of the common red variety. This mammoth clover, as will be seen by reference to the table below showing composition of the crops, is not inferior in nutritive value to the common. The mammoth is to be especially recommended for sowing in mixtures of which timothy is a prominent part, as it matures more nearly with this grass than does the common red.

Common red clover calls for little special comment. Each of the three cuttings was made when the crop was a little past full bloom; the dates, June 19, July 28 and October 9. The average total yield of the plats (one-tenth of an acre each) is at the rate of a little more than 4¼ tons per acre. The composition of this variety will be found in the table which follows those showing yield and dry matter.

Alsike clover gave two excellent crops, cut respectively on June 19 and August 10: but, while the sod of both the mammoth and common red on November 3 appeared to be in excellent condition, the sod of this variety shows signs of weakness. Weeds are coming in to a considerable extent, principally sorrel. The table of composition shows this clover to be somewhat richer in nitrogenous nutrients (protein) than either of the others. This difference in its favor is in part offset by lower percentages of fat and extract, and it is doubtful whether the hay of this variety is worth more for food than that of either of the others. Alsike clover is especially recommended for soils which are rather too moist for the common red variety.

FIELD B. — *Trial of Clovers (Bone at Rate of 600 Pounds per Acre to All Plats).*

	Mammoth Clover.		Common Red Clover.		Alsike Clover.		Crimson Clover.	
	Plat 13. Muriate of Potash.	Plat 14. Sulphate of Potash.	Plat 15. Muriate of Potash.	Plat 16. Sulphate of Potash.	Plat 17. Muriate of Potash.	Plat 18. Sulphate of Potash.	Plat 19. Muriate of Potash.	Plat 20. Sulphate of Potash.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
First crop,	615	650	456	455	620	455	575	595
Second crop,	295	305	276	294	325	200	-	-
Third crop,	-	-	120	120	-	-	-	-
Total crop,	910	955	851	869	945	655	575	595

FIELD B. — *Clovers (Dry Matter in the Crops).*

	Mammoth Clover.				Common Red Clover.				Alsike Clover.				Crimson Clover.			
	Plat 13.		Plat 14.		Plat 15.		Plat 16.		Plat 17.		Plat 18.		Plat 19.		Plat 20.	
	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.
First crop,	83.19	511.6	83.32	541.6	82.1	373.5	85.7	390.1	74.0	458.5	78.4	356.5	73.6	422.9	68.4	406.9
Second crop,	83.06	245.1	83.52	254.7	77.3	213.2	78.4	230.5	84.6	274.7	81.0	162.0	-	-	-	-
Third crop,	-	-	-	-	83.3	99.9	83.3	99.9	-	-	-	-	-	-	-	-
Total dry matter,	756.7		796.3		686.6		720.5		733.2		518.5		422.9		406.9	

Composition of Clover Hay.

POTASH SALT.	MAMMOTH.		COMMON RED.		ALSIKE.	
	Muriate (Per Cent.).	Sulphate (Per Cent.).	Muriate (Per Cent.).	Sulphate (Per Cent.).	Muriate (Per Cent.).	Sulphate (Per Cent.).
Water,	16.81	16.88	17.92	14.26	26.05	21.64
Dry matter,	83.19	83.32	82.08	85.74	73.95	78.36
	100.00	100.00	100.00	100.00	100.00	100.00
Dry matter contains: —						
Crude ash,	9.97	8.96	8.79	8.22	10.67	9.77
Crude cellulose,	30.35	30.40	31.46	30.24	30.32	30.23
Crude fat,	2.00	2.18	2.66	3.15	2.07	2.08
Crude protein,	14.65	14.86	13.34	12.61	16.48	15.82
Nitrogen-free extract matter,	43.03	43.60	43.75	45.78	40.46	42.10

Sulphate v. Muriate of Potash for Clovers. — This experiment with clovers was so carried out as to allow a careful comparison between the sulphate and the muriate as sources of potash for this crop, as well as the comparisons between varieties. A study of the figures giving yields shows that there seems to be no clearly defined difference in the effect of the two salts upon the total product. It is true that in the case of the alsike clover the muriate plat produced much the larger crop; but, since this was not the case with either of the other varieties, we are not justified in concluding that this difference is a direct consequence of the different manuring.

A study of the figures showing the composition of the crops from the several plats, however, reveals the fact that in every instance the percentage of nitrogen-free extract is greater in the hay raised on the sulphate of potash. It is true that the difference is not large, though in the case of the red clover it is sufficient to make a difference of rather over 140 pounds of this valuable class of nutrients in the product of one acre. It seems probable that this difference is due to the action of the chlorine of the muriate of potash in decreasing the formation of starch, — an effect which has often been noticed with the potato. Since, then, starch is

one of the most valuable constituents of foods, it follows that the sulphate is to be preferred to the muriate of potash, if it can be obtained at the same price. This, however, has not thus far been the case. At prevailing prices, the muriate would seem likely to be the more profitably employed.

4. *Millets for Seed.*

The three species of Japanese millet reported in previous years have been again cultivated for seed. The product has been at the following rates per acre: barn-yard millet (*Panicum crus-galli*), straw, 6,554 pounds, seed, 57 bushels; Japanese panicle millet (*Panicum miliaceum*), straw, 5,514 pounds, seed, 26 bushels; common Japanese millet (*Panicum italicum*), straw, 5,017 pounds, seed, 53.3 bushels. The weights per bushel of the seed are respectively 35, 54 and 42 pounds. Owing to unfavorable weather, a large amount of the seed of the barn-yard millet wasted in the field, hence the yield appears smaller than it actually was.

5. *Millets for Fodder.*

(*a*) *First Experiment.* — Our three species of Japanese millets, viz., the "barn-yard," the "panicle" and the "common," have been carefully compared with each other and with Hungarian grass as fodder crops upon a somewhat extensive scale. Nearly one-half an acre of the barn-yard variety and one-third of an acre each of the others were sown. The soil was a rather heavy loam, which for several years has been manured only with fertilizers. On a part of each plat the fertilizers applied were bone meal, lime and double sulphate of potash and magnesia; on the balance of each, nitrate of soda, Thomas phosphatic slag and the double sulphate were applied. To Dr. Goessmann is left the discussion of the results of the two systems of manuring, as they were planned by him. We have here to do only with the comparison of the varieties under trial. Suffice it to say that the fertilizers were applied in only moderate amounts, and that they were spread after ploughing, and harrowed in. All varieties were sown on June 2, the seed covered with Breed's weeder and the land then rolled.

The following table shows the amount of seed sown, the date of cutting and the yield of well-cured hay. For convenience of comparison, the yield of the "barn-yard" variety is given for the same area as the others: —

Varieties of Millet (One-third Acre Each).

VARIETY.	Quantity of Seed sown (Quarts).	Date of Cutting.	Yield of Hay (Pounds).
Hungarian grass,	$6\frac{1}{2}$	Aug. 15,	1,730
Japanese common millet,	8	Aug. 26,	2,025
Japanese panicle millet,	8	Aug. 15,	2,410
Japanese barn-yard millet,	$4\frac{1}{3}$	Aug. 15,	2,603

The fact must be stated that the quantity of seed of the "barn-yard" variety proved to have been rather too great for a season so favorable for rank growth as was the last. The crop of this variety lodged badly, and was therefore cut rather before it would otherwise have been. It was the intention to cut each variety when the seed of the plants on the earliest portion of the plat was well formed, but before it began to harden; and this was done except in the case of the barn-yard variety, which, as before stated, was cut a little before this stage was reached. The several varieties yielded, as determined by calculation from the results given in the above table, at the following rates per acre of well-cured hay: Japanese barn-yard millet, 7,830 pounds; Japanese panicle millet, 7,230 pounds; Japanese common millet, 6,075 pounds; and Hungarian grass, 5,190 pounds.

(*b*) *Second Experiment.* — Seventeen varieties of millet, including the 4 above discussed, were given a trial upon a smaller scale, upon similar soil and under similar conditions to those just described. The plats in this experiment were ten rods long and one rod wide, containing, therefore, one-sixteenth of an acre each. The results are shown in the table which follows: —

Millets, Variety Tests (Plats One-sixteenth Acre Each).

	Quantity of Seed (Quarts).	Height of Plants (Inches).	Date of Cutting.	Yield of Hay (Pounds).
Canary bird seed,* . .	2	30	Aug. 25,	295
Early Harvest, . . .	2	36	Aug. 4,	325
Mukodamaski (Japanese),	2	42	Sept. 8,	540
Golden, . .	2	54	Sept. 8,	610
Golden Wonder, . .	2	48	Aug. 13,	480
Hokkaido (Japanese), .	2	47	Aug. 25,	430
Japanese common, . .	2	48	Aug. 25,	475
Hungarian, .	2	39	Aug. 13,	550
Japanese white panicle, .	1½	78	Aug. 31,	840
Chinese, . . .	1½	51	Aug. 4,	460
Common broom corn, .	1½	40	July 28,	450
White French, . . .	1½	48	July 31,	310
Red French, . . .	1½	34	July 28,	300
Hog, ...	1½	37	July 28,	370
California, . . .	1½	37	July 28,	370
Japanese panicle, . .	1½	55	Aug. 15,	490
Japanese barn-yard, .	1	66	Aug. 13,	620

* In this table the names under which the varieties were advertised are used in the case of all purchased sorts. The Japanese varieties are of our own importation or production.

The varieties especially noteworthy for large production are the Japanese white panicle and the Japanese barn-yard, the latter not doing its best either in this trial or the other, on account of having been sown too thick. In estimating the significance of these results, this fact must be kept in mind. It is further important to state that the barn-yard variety is far less harsh and woody than any of the other large-growing varieties of millet. Its extreme succulence, however, makes it rather difficult to cure. We have had most success in handling it as clover is usually handled by the best farmers, viz., by curing mostly in the cock. It is our intention to publish analyses of these millets in a later report or bulletin.

Miscellaneous Crops.

A considerable number of miscellaneous crops have been under trial upon a small scale, or have been cultivated for illustrative purposes. Under this class may be included 37 species of grasses; 22 varieties of millet for seed; 26 species and varieties of leguminous fodder or green manur-

ing crops; 7 varieties of oats; several varieties of sorghum recommended for fodder, — saccaline, iris, beggar weed and cystisus, all sent in for trial as fodder crops; Ankee grass and 2 varieties of sugar beets. Many of these require no especial notice, while most of the others can be sufficiently discussed in a few words.

The grasses include a considerable number of species, received through the kindness of Professor Fletcher of the Ontario Agricultural College, which are as yet entirely unknown to the general cultivator. Several among them are indigenous to America, and appear to possess qualities which fit them in an especial degree for our soil, climate and conditions, and must make them of great value in our agriculture. The seeds of all these grasses were sown last spring, and it therefore follows that they have not yet had a trial sufficiently long to warrant definite conclusions. Among those species, however, which, so far as can be judged from one season's growth, appear to be expressly promising, are the following: *Bromus schradeii*, *Bromus ciliatus*, *Agropyrum tenerum* and *Avena flavescens vera*. Seven indigenous species from seed collected in Amherst and vicinity are under trial, and two species were sent for trial by the United States Department of Agriculture. One of these, *Eragrostis New Mexicana*, appears promising; the other, *Elensine Egyptiaca*, gave one good cutting, but failed to start thereafter. If an annual, as this behavior indicates, it can hardly prove important.

The Millets. — Among the 22 varieties included in this trial are most of those cultivated as fodder crops, besides a few others which were of especial interest. In this trial all varieties were allowed to ripen seed. As it was, however, found impossible to prevent the birds from taking some of the seed, — a serious matter, where the quantities are small, — it is not deemed important to publish the figures showing yields.

It has been decided, after the experience of two years in cultivating these varieties both for fodder and for seed, *that there is no appreciable difference between the varieties sold by various seedsmen under the following names: White French, Chinese, broom corn and California.* This variety, as well

as the French, red French and hog millets, are all apparently of the same species as the Japanese panicle millet, viz., *Panicum miliaceum*, and are all much inferior to the Japanese in productive capacity, and inferior, I believe, also, to Hungarian grass.

Leguminous Fodder and Green Manuring Crops.

Most of the species and varieties, 26 in number, coming under this class, have been named, described and commented upon in previous reports, and require no further mention at this time. Of a few it is necessary to speak briefly.

1. *Flat Pea* (*Lathyrus sylvestris*). — Of all the crops which have been urged upon the attention of the American farming public in recent years, few have been so highly praised as this. I am compelled to conclude, after three years' trial, and in view also of the experience of others, that it is not a crop which can prove valuable among us. The principal points against it are the following: —

(*a*) The seed germinates with extreme slowness and uncertainty, making this a difficult and expensive crop to start. It would hardly be possible to stock a field with it, except by starting the plants in a bed and then transplanting to the field.

(*b*) The plants are not perfectly hardy under average conditions.

(*c*) The plants in growing sprawl over the ground in such a manner as to make this a difficult crop to cut.

(*d*) The forage is not relished by cattle. This statement is based largely upon distinguished German authority.*

In conclusion, I may state that this crop does not appear to have made any important place for itself in the land of its origin, Germany.

2. "*Sweet Clover*" (*Melilotus alba*). — Two plats in Field B, each of one-tenth of an acre, were sown with this clover, as it was thought possible that it might prove useful for the silo or for green manuring. These plats are designated by numbers 10 and 11. Both received ground and steamed bone meal at the rate of 600 pounds per acre;

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* Dr. Max Maercker and Dr. Julius Kuehn.

Plat 10, muriate of potash; and Plat 11, high-grade sulphate of potash, in both cases at the rate of 200 pounds per acre. The seed was sown at the rate of 3 pounds per plat. The plants were badly thrown out of the ground during the winter, but most of them survived. The growth, however, was poor, and both were cut June 19, yielding: Plat 11, 200 pounds; Plat 12, 285 pounds, green weight.

It was noticed that isolated plants or clumps of plants while growing had a much deeper shade of green, and were in many instances three times the average height of the other plants in the field. Examination revealed the fact that in every instance the roots of these plants were thickly set with the nodules characteristic of the Leguminosæ, while such nodules were either entirely or almost entirely absent from the roots of the feebler plants, which class included a large majority of those in the plats. It is believed that this difference accounts for the wide variation in the different plants. These nodules are due to the development upon the roots of specific bacteria (microscopic fungi). These bacteria must develop, like other plants, from seed; and this seed, when the culture of a new crop of this class is first begun in a given locality, is not present as a rule in such quantity as to insure a full development of the nodules. Such as do develop must come from spores which adhere to the seed of the new crop. In the case of a second or later crop the spores are more abundant, for, as is often the case with weed seeds, the few developed the first year, remaining in the soil with the roots of the crop, retain their vitality, and accordingly the crop does better when grown a second or third time than at first, because the more abundant spores cause a more abundant development of root nodules upon which the assimilation of free atmospheric nitrogen depends.

In this case sweet clover had never been grown upon these plats before; hence, as there were probably no spores in the soil, and nodules could come only from the few spores which happened to adhere to the seed sown, there were in the aggregate but few and the crop did poorly. The plats have been sown again with the same crop, in the expectation that in the second year of its culture it will do

better. The probability that this will be the case should never be lost sight of when new leguminous crops are under trial.

3. *The Horse Bean* (*Vicia faba*). — This crop, so highly prized by Professor Robertson of Ontario, has been given a rather more extensive trial than most of the crops in this class during each of the last two years. It does not commend itself to my judgment as a fodder crop, for which it is recommended. It is subject to a blight, which often seriously injures it; it sets comparatively little seed, most of the blossoms blighting; and in yield it does not equal other leguminous crops which are more easily cultivated.

4. *Field Peas.* — During the past season we have tried three new varieties of field peas from Canada, all of which appear to be excellent sorts for field culture with oats or barley as fodder crops. There does not appear to be a very wide difference between the three in productive capacity. All were remarkably free from mildew. The table below gives all information necessary for a comparative estimate of these varieties: —

Field Peas (2 Rows, Each 70 Feet Long).

	English Gray.	Canada Beauty.	Prussian Blue.
	Pounds.	Pounds.	Pounds.
Total yield, pods filled but vines still green,	165	200	205
	Per Cent.	Per Cent.	Per Cent.
Dry matter,	14.77	18.28	18.06
Water,	85.23	81.72	81.94
	100.00	100.00	100.00
Dry matter contains: —			
Crude ash,	9.56	7.80	–
Crude cellulose,	30.23	28.99	–
Crude fat,	3.16	2.74	–
Crude protein,	20.65	16.14	–
Nitrogen-free extract,	36.40	44.33	–
	100.00	100.00	–

It is noticeable that the first variety is considerably richer in protein than the others; but, as the yield is so much smaller, either of the latter would seem to be preferable as fodder crops. They not only yield more heavily, but the fodder contains a considerably larger percentage of dry matter, which gives them greater food value. It might be thought that the Canada Beauty and Prussian Blue must have been more mature than the others, but this is not believed to have been the case. The effort was to harvest each in the same stage of maturity. Moreover, all were planted on the same date, May 2, and they were harvested as follows: English Gray, July 11; Canada Beauty, July 14; and Prussian Blue, July 2.

Oats. — Five varieties of *common oats* were tried upon a small scale, chiefly with a view to determining whether a variety could be found capable, under our peculiar climatic and soil conditions, of resisting rust. The attempt was a failure so far as this particular object is concerned, as all varieties rusted, and apparently to practically the same extent. The crop, however, was a fairly good one. The area occupied by each variety was 7 by 85 feet (one seventy-third of an acre). The yield is shown below: —

Varieties of Oats (One Seventy-third Acre Each).

	Straw (Pounds).	Grain (Pounds).	Weight per Bushel (Pounds).
Siberian,	57	30	32
Lincoln,	52	34	31
Black Beauty,	66	35	29½
New Illinois,	59	32	30½
White Poland,	52	27	33

A yield of 31 pounds is almost exactly at the rate of 70 bushels of 32 pounds each per acre.

Winter Oats. — Two varieties of winter oats have been tried during the past year. The seed of one sort was obtained from Dover, Del., of the other from Charlottesville, Va. In both of these States winter oats are considerably cultivated, and, as the impression there seemed to be that

these oats are quite hardy, it was decided to try them. We were also invited by Peter Henderson & Co. to make such a trial. One plat of one-tenth of an acre in rather heavy but well-drained loam and another of about three-eighths of an acre in medium loam were selected for the experiment. The seed was sown in drills about the last of September, and the oats had made a good start before cold weather. *Not a single plant survived the winter in either plat.*

Sorghum Varieties. — Several varieties of reputed fodder plants belonging to the genus *Sorghum* have been under trial in a small way during each of the last few years, usually at the suggestion of the United States Department of Agriculture. It is believed by some of the officers of this department that plants of this class, having greater capacity to resist drought than many others, will prove valuable fodder plants; and this opinion is seemingly justified by the results of trials in some of the western States. In Kansas, indeed, very favorable results have been obtained with some of them as grain crops. Such of these crops as have been tried here have always been put in warm, well-drained soil, but they have in no instance equalled Indian corn as fodder crops. Those tried this year are the following: "Jerusalem corn," "Red Kaffir corn," "White Kaffir corn" and "Millo maize." "Teosinte," although not a sorghum, can be considered with them. All of these grow very slowly at first, which increases the cost of culture largely, as compared with corn. None of them have ripened seed with us. *For the various reasons above stated, I do not regard any of these crops as likely to prove valuable for Massachusetts farmers.*

Saccaline. — Seed obtained in 1895 was started in a bed in the open air, and in midsummer plants were set in two plats, one in light sandy soil, the other in a heavy moist soil. The plants in the latter grew vigorously until late fall, those in the sandy soil but feebly. During the winter about 75 per cent. of the plants in both plats were killed. A similar proportion of plants temporarily set in a bed in medium loam died during the winter. Such plants as survived the winter in the moist soil made a very early start in the spring, but were entirely destroyed by later frosts. I judge that the plant is far from being sufficiently

hardy for our climate. Moreover, it is not much relished by stock unless cut very young. Further, it should be remembered, by any one trying it in a locality where it thrives, that it spreads rapidly by means of underground stems, and that it is extremely difficult to eradicate when once it has gained possession of the ground.

Iris pabularia. — Seeds were sent for trial by J. M. Thorburn & Co. of New York in 1895, the statement being made that it might prove valuable as a fodder crop. Germination was slow, the plants grew but feebly and during last winter all were killed.

Cystisus proliferus albus. — Seeds were received for trial of this plant as a fodder crop in the spring of 1895. Germination was imperfect, the plants did not make much growth and all died during last winter.

Florida Beggar Weed (*Desmodium tortuosum*). — Seeds sent for trial as a possibly valuable fodder crop were sown May 4. The plants grew to be about 3 feet tall, with numerous branches and leaves, which are eaten by stock. The main stem is hard and woody. The amount of fodder produced does not equal that produced by the soya bean in the same time. The plants did not reach the blossoming stage and were killed to the ground by the first frost. I judge that it will have no value here as a fodder plant.

Spurry (*Spergula arvensis*). — Two varieties, "small" and "giant," were under trial on a small scale. Neither produced fodder enough to make it of value.

Ankee Grass (*Panicum crus-galli*). — Seed of a variety of this species (the same as that to which our Japanese barnyard millet belongs) was received from the United States Department of Agriculture, with the request that we submit it to trial. It was stated that it had been collected by C. R. Orcutt, and that the seed was used as food by the Indians of South California and Arizona. The seed was sown May 4, and the crop was given careful culture. The plants grew about 5 feet tall, the stems were coarse, harsh and woody, brown in color, quite leafy. Panicles open like those of the common weed (barn-yard grass), but without awns, large. Seeds did not ripen. As compared with the Japanese barnyard millet, this variety is not as tall, coarser and more

woody and much later. It is decidedly inferior to the Japanese variety in every respect as a fodder crop for this locality. It is quite probable, however, considering its origin, that the Ankee grass will endure drought better than the Japanese barn-yard millet.

Millets under False Names. — The reputation of some of our Japanese millets is such that seed has for the last two years been offered in some quarters which is not genuine. We have received and tested three such samples, from widely different sources. In one of these cases the mistake may have been inadvertent. The variety was sold as Japanese barn-yard millet; it proved to be the Japanese panicle millet, — a widely different sort. *It should be remembered that we have sent out three Japanese millets, viz., the barn-yard, panicle and common. The first we consider to be the most valuable as a fodder crop.*

Sulphate of Iron as a Fertilizer.

A recent English work on manures and fertilizers* lays great stress upon the value of *sulphate of iron* as a fertilizer, and contains figures giving the results of many apparently careful experiments, all tending to show that this chemical often has a considerable influence in increasing crops. The opinions of Mr. Griffiths upon this point, so far as I am aware, are not shared by most authorities, and I had not much confidence that experiments here would give results similar to those he reports. Still, it is our place to put such questions to the test. Accordingly a piece of land that for some years has been manured yearly at the rate of 600 pounds ground bone and 200 pounds muriate of potash per acre, and which has produced a variety of crops, including grass, potatoes and clover, was selected for the purpose. It was divided into four plats, and all received the customary application of bone and potash, applied in September, 1895. These plats contain one-thirtieth of an acre each. The crop was the medium green soya bean, planted June 13. Sulphate of iron was applied to two of these plats, Nos. 1 and 4, on June 24, just as the beans were coming up, at the rate of 80 pounds per acre.

* Griffiths, "Farm Manures."

It has been claimed by Griffiths that the use of this salt favors chlorophyll formation, and that it therefore causes a perceptibly deeper shade of green in the leaves in the plants to which it is applied. No difference could be detected during the season. The average crop (cut green for the silo) where the sulphate of iron was applied was 462½ pounds, the average of the other plats 445 pounds, — a difference of 17½ pounds in favor of the treatment, or at the rate of 525 pounds per acre. I consider this difference too small to be of much significance.

"Bug Death."

This is a preparation sent to us by the Danforth Chemical Company, Leominster, Mass., as a substitute for Paris green as a poison for potato bugs and as a preventive of blight. It was received late in the season, the "bugs" being full grown when we were able to use it the first time. It kills them, but not as quickly as Paris green; and as, in showery weather particularly, rapidity of action is desirable, I do not look upon it as equal in value to that poison for this and similar purposes. The "Bug Death" had no apparent effect in preventing blight.

Atomizer for applying the Bug Death.

The Danforth Chemical Company sent with the "Bug Death" a large atomizer, which they recommended for its application. This material and similar dry poisons can be applied with this atomizer, but it is entirely unsuited to use upon a large scale. The hand soon becomes excessively and painfully weary from the motion required, while the time occupied is far greater than by other means which are within the reach of all. It required twenty-eight minutes to cover a row with the atomizer, while the same length of row was covered by the use of Leggett's gun in eight minutes.

Fungiroid.

"Fungiroid," sold by the manufacturers of Leggett's dry insect powder gun as a means of preventing potato blight, has been given a thorough trial. Both the "*Fungiroid" in combination with Paris green*, furnished and recommended by the company, and in the latter part of the season, when

the bugs had ceased to be troublesome, the *pure "Fungiroid,"* were employed. The season was hot, with frequent showers, furnishing, therefore, conditions highly favorable to the development of parasitic fungi, and extremely unfavorable to the action of the "Fungiroid." It was, however, reapplied at frequent intervals, and always after a heavy rain and while the vines were moist.

The treatment was applied to one row each of the 60 varieties in our variety test. One row each of 38 of these varieties, in an adjoining plat, upon similar soil and grown under precisely similar conditions, was left untreated. No difference whatever could be detected in the extent to which blight affected the treated and untreated vines. "*Fungiroid" and Paris green mixture* (prepared) was applied at the rate of 2 pounds per acre to the vines of the treated plat with Leggett's gun, and in accordance with directions, on each of the following dates: July 13, 18, 22 and 24. Pure "Fungiroid" was applied twice, at the rate of 1½ pounds per acre, and in the same manner, on August 1 and 3. By the latter date blight had affected all varieties in the plat and to a considerable extent in most cases. The yield from 38 rows treated as described was 7,887½ pounds of large and 983 pounds of small potatoes. The 38 rows which were untreated produced 8,407 pounds of large and 960 pounds of small tubers. The results surely indicate no favorable influence due to the use of "Fungiroid."

Scab of Potatoes.

It has been thought by some experimenters that, by an application of sulphur at the time of planting, "scab" of potatoes, even in infected soil, could be prevented. Accordingly, as we had such an infected soil where a very scabby crop was raised last season, it was decided to test this point. The plan of the experiment was as follows: one-half the seed required was treated with corrosive sublimate solution in the usual way; then 240 hills were planted with each kind of seed (treated and untreated), and in the furrow with one-half of these hills sulphur at the rate of 300 pounds per acre was scattered at time of planting. The table below shows the results: —

Sulphur for Prevention of Scab of Potatoes (120 Hills Each).

TREATMENT.		Large Tubers.			Small Tubers.
		Free of Scab (Pounds).	Slightly Scabby (Pounds).	Badly Scabby (Pounds).	
Seed treated with corrosive sublimate,	no sulphur,	21	78½	48	24
	sulphur,	2	80½	56	15
Seed untreated,	no sulphur,	2 tubers	70½	84½	19½
	sulphur,	3 tubers	67	96	20

The use of sulphur in the drill appears to have been absolutely without effect. The table indicates that even when seed is planted in infected land the treatment with corrosive sublimate is somewhat beneficial.

Trial of Hay Caps.

Another season's use, and very frequent and extended use, of the three styles of hay caps mentioned in my last report, viz., the Symmes' paper board, oiled cotton and cotton impregnated with tannin, has led to the following conclusions: —

1. Caps of some sort are extremely useful, especially with such crops as clover, millets, oats and peas, and other slow-curing crops, especially those much injured by excessive handling.

2. The Symmes' cap is most quickly applied, — an important point, — and is best liked. It appears to be wearing very well.

3. Of the two styles of cloth caps in use, those impregnated with tannin are most durable. The oiled caps are more mildewed than the others and have become much more torn.

4. It has been found that in some cases, where clover has been cocked quite green and covered with the three kinds of caps and allowed to stand for some time with frequent rains, it has kept better under the cloth than under the Symmes' caps. The porosity of the former in such cases appears to be an advantage.

Poultry Experiments.

Poultry experiments were continued during the winter of 1895–96 upon a small scale. Our attention has been confined to two points, viz. : —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of dry ground animal meal and cut fresh bone.

1. *Effect of Condition Powder upon Egg-production.*

The experiment to test the value of condition powder in feeding for eggs was begun February 9 and continued until April 28. We used two lots of fowls, selected with the utmost care with respect to similar characteristics in the two lots. Each lot contained 3 barred Plymouth Rock hens, 8 light Brahma hens, 6 light Brahma pullets and 2 Wyandotte-light Brahma pullets. The hens were one and three-quarters years old at the time the experiment began. Each lot, consisting of 19 fowls, occupied a detached house having two compartments (scratching shed and closed roosting and nest room), respectively 8 by 12 and 10 by 12 feet in size, the nest room with two windows. These houses adjoin each other and both have precisely the same exposure. The two lots were fed as follows: in the morning they received a mash which was mixed hot the previous evening; at noon, and again one hour before sundown, whole grain was scattered in the straw in the scratching sheds. Artificial grit, oyster shells and pure water were kept always before them. The only difference in the management of the two lots was that condition powder was mixed in the mash for one lot, in accordance with directions furnished with the powder. This experiment seemed important, in view of the large amount of money, in the aggregate, which is expended in the purchase of such powders; and, notwithstanding the very general impression that they are useful, in the absence of any definite proof of the fact. *I would call especial attention to the fact, — which, though generally well known, is often lost sight of, — that no one experiment can settle this question in the one way or the other.* The results of this experiment are pub-

lished, then, not as settling the question, but simply as evidence bearing upon an important point, to be accepted only for what it may be worth.

The foods used in this experiment and in the other described later, and their composition, are shown below: —

Composition of Air-dry Foods used in Poultry Experiments (Parts in 100).

	Water.	Crude Ash.	Crude Cellulose.	Crude Fat.	Crude Protein.	Nitrogen-free Extract.
Ground clover, . . .	9.53	7.43	27.80	1.93	13.65	39.66
Wheat bran, ...	9.56	5.27	8.85	5.37	17.69	53.26
Animal meal, . . .	5.08	28.63	–	16.18	40.03	10.08
Cut bone, ...	29.67	24.06	–	26.13	20.19	–
New-process linseed meal, .	9.35	4.48	6.58	6.39	38.06	35.14
Buffalo gluten meal, . .	7.14	.84	7.07	12.67	23.31	48.97
Chicago gluten meal, . .	8.10	.83	3.34	5.57	36.51	45.65
Wheat middlings, . .	10.93	4.03	6.95	5.30	17.28	55.51
Whole wheat, . . .	10.60	1.69	2.17	1.93	13.19	70.42
Whole oats, ...	10.06	2.77	8.71	4.87	14.53	59.06
Soya-bean meal, . . .	9.24	5.02	3.87	16.25	34.75	30.87

The kinds and total amounts of the several foods used in this experiment for the lot of fowls having condition powders are as follows (in pounds): whole wheat, 100; whole oats, 99.5; wheat bran, 19.8; wheat middlings, 19.8; ground clover, 19.8; new-process linseed meal, 9.9; animal meal, 9.9; soya-bean meal, 9.9; cut bones, 3. Two pounds of condition powder were used. All the meals, bran, middlings, ground clover and bones were given in the form of the morning mash. The total number of pounds of food used was 291.6. The nutritive ratio, based upon composition (as digestibility by fowls is not known), is 1 : 4.5. The cost of all the food used was $3.43, not including the condition powder.

The lot of fowls which received no condition powder received foods as follows (in pounds): whole wheat, 99.5; whole oats, 100; wheat bran, 19.3; wheat middlings, 19.3; ground clover, 19.3; new-process linseed meal, 9.7; animal

meal, 9.7; soya-bean meal, 9.7; and cut bone, 3. Total number of pounds, 289.5; total cost, $3.39; nutritive ratio, 1:4.5.

The results and leading details of the experiment are shown in the table below: —

Condition Powders for Egg-production.

Experiment, February 9 to April 28.	Duration of Experiment.	Total Food consumed.	Cost of Food per Day per Fowl.	Number Eggs produced.	Dry Matter in Food per Egg.	Cost of Food per Egg.
	Days.	Pounds.	Cents.		Pounds.	Cents.
19 fowls, condition powder, . . .	79	291.6	.23	163	1.611	2.1
19 fowls, no condition powder, . .		289.5	.23	195	1.333	1.8

In the above estimate the cost of the condition powder is not included. This amounts to $1, which would make the cost per egg 2.7 cents in the case of the fowls receiving it.

The fowls receiving no condition powder laid their first egg on February 12; those receiving it, their first egg on March 16, at which time the other lot had laid 24 eggs. One hen in each lot died during the experiment. At its close the fowls in both lots appeared to be in about equal condition of health, but two in the condition-powder lot had begun to moult, while there were no indications of moulting in the other lot. There was no material difference in the size or appearance of the eggs from the two lots. This experiment is now being repeated, with lots of pullets most carefully selected with reference to it, having been begun on Jan. 1, 1897.

2. *Animal Meal v. Cut Bone for Egg-production.*

The general conditions of this experiment were similar to those in the experiment to test the value of condition powder. Each house contained 2 barred Plymouth Rock and 10 light Brahma hens, 5 light Brahma pullets and 2 white Wyandotte-light Brahma pullets; total, 19 fowls. The experiment began February 9 and ended April 28.

The food received by the lot having cut bone was as follows (in pounds); whole wheat, 99.5; oats, 100; wheat

bran, 18.5; wheat middlings, 18.5; Chicago gluten meal, 18.5; ground clover, 18.5; cut bone, 10; total, 283.5 pounds; cost, $3.25; nutritive ratio, 1 : 4.8.

The other lot received essentially the same foods, except that in place of the bone it got 9.7 pounds of animal meal; total food, 287 pounds; cost, $3.26; nutritive ratio, 1 : 4.9.

The leading details and results are shown in the following table: —

Cut Bone v. Animal Meal for Egg-production.

Began February 9, ended April 28.	Duration of Experiment.	Total Food consumed.	Cost of Food per Fowl daily.	Number of Eggs produced.	Dry Matter in Food per Egg.	Cost of Food per Egg.
	Days.	Pounds.	Cents.		Pounds.	Cents.
Cut bone lot, ...	79	283.5	.22	269	.940	1.2
Animal meal lot, ...		287.0	.22	145*	1.796	2.2

* One soft shelled.

In the above estimate of cost the labor required to cut the bones is included. The results indicate a decided advantage in favor of the bone. During last year two experiments were tried, one of which resulted favorably to the bone, the other to the animal meal. Last year there was some diarrhœa among the fowls having bone, this being given alone. This year the bone was fed in the mash, and there has been no such trouble. There has been this year no perceptible difference either in the condition of the fowls in the two lots or in the size or character of the eggs produced. The experiment indicates, then, a decided advantage in favor of the cut bone. This experiment is now being repeated.

REPORT OF THE METEOROLOGIST.

LEONARD METCALF.

During the past year the usual meteorological observations have been continued, and the results have been compiled with those of previous years. A special bulletin will be published with the annual summary of observations for the year 1896, in January, 1897, giving the mean annual and the maximum and minimum records for this station for the past eight years, *i.e.*, since the equipment of our observatory.

The advisability of making a change in the time and frequency of taking the observations, from tri-daily readings at 7 A.M., 2 P.M. and 9 P.M., to bi-daily readings at 8 A.M. and 8 P.M., to conform with the present method of the U. S. Weather Bureau, was considered; but, after discussing the subject thoroughly with the department at Boston and at Washington, it was deemed unwise to make the change, and the observations have therefore been taken three times a day, as heretofore.

After a careful study of the thermometer records of the tower shelter, it was found that the local conditions of exposure were such as to seriously affect the accuracy of the temperature readings, and the Draper thermograph, by which the mean daily air temperature at the tower was found, was removed to the ground shelter, where its readings are checked and corrected three times a day by a standard mercury thermometer and by the maximum and minimum thermometers previously kept there. While record is still kept of the maximum and minimum air temperatures in the tower shelter, it is no longer published. The wet and dry bulb thermometers were also removed to the ground shelter, and the wet-bulb reading or "sensible temperature" of the air is now published, as well as the dry-bulb reading. This "sensible

temperature" is of course the temperature of the atmosphere as we ordinarily feel it, as the sensible temperature is directly dependent upon the relative humidity of the air, and hence upon the cooling effect of the evaporation of the surface moisture.

After a careful comparison of the rainfall records of the ground and the tower, obtained in each case by United States Weather Bureau rain gauge, it was found that the tower records were so affected by upward wind currents, due to the shape of the roof, as to render them of very doubtful value. The tower "precipitation" observations have therefore been discontinued.

Some additional records have been kept during the past year and will be continued this year. Among these are the number of days of sleighing and the amount of snow on the ground at the beginning of each week, the latter being reported to the New England Weather Bureau weekly. Record has also been kept of the accuracy of the forecasts received daily at this station; this record shows that, while the monthly percentage of correct forecasts has varied from 69 per cent. to 90 per cent. during the year, the mean percentage of accuracy of forecasts has been 78 per cent.

A few new instruments have been added to the station's equipment: two sets of Green maximum and minimum thermometers; six mercury thermometers, United States Signal Service pattern, made by Green; and a thermophone,* with four resistance temperature coils, made by E. S. Ritchie & Sons, the latter instruments being intended for experiments on soil temperatures.

Through the courtesy of Professor Whitney, one of his assistants, Mr. Thomas H. Means of the Division of Soils, Department of Agriculture, was sent to Amherst in the middle of July to install a set of Professor Whitney's apparatus for the determination of soil temperature and moisture. Soil-temperature electrodes and moisture-resistance plates were buried in grass land, a short distance from the ground shelter, at five different depths, from the surface of the ground to a depth of two feet; and from that time, the middle of

* The thermophone was recently designed and patented by Messrs. Henry E. Warren and George C. Whipple.

July, until the latter part of August, when the reading instrument broke down, daily records of the soil temperature and moisture were taken. The reading instrument above referred to was designed by Professor Whitney, and is a form of Wheatstone's bridge, reading the electrical resistance of the temperature cell and of the soil itself, from which data the temperature and moisture of the soil are computed.

Early in September the thermophone was received from Messrs. Ritchie & Sons, and its temperature-resistance coils were buried not far from the Whitney apparatus, at depths of three, twelve, twenty-four and thirty-six inches respectively. On this have been taken tri-daily soil temperature observations to the present time, and these records will be continued throughout the winter, the results being plotted each month, at its close, for purposes of comparison.

In the spring the thermometer coils will probably be taken up and put down in another place for observations, together with other instruments, on soil and air temperatures on an experimental corn plot; as plans have been formulated in co-operation with Doctors Allen, True and Whitney of the Department of Agriculture at Washington, and considerable work has been done preliminary to undertaking at Amherst a series of experiments bearing upon soil temperatures and moistures in their relation to the growth and advancement of crops.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The number of varieties of fruits tested during the past season has been greatly increased, and the testing of a large number of varieties of vegetable seeds has been added to the work.

A large addition of varieties of apples, Japanese plums, peaches, cherries and the new species of raspberries and blackberries has been made by purchase of young stock, or by budding or grafting into stocks already established.

Spraying.

The protection of fruit and garden crops from insects and fungous pests has formed an important part of the work of this division, the results of which again emphasize the fact that good fruit cannot be grown without more or less use of insecticides and fungicides. The most approved apparatus and the new methods of application, as well as the new insecticides and fungicides, are given a very careful trial as soon after their introduction as possible.

The insecticides most used are Paris green, kerosene emulsion, hellebore and pyrethum or insect powder. In the greenhouses lemon oil has proved the most valuable substance for keeping down scale and mealy bugs.

The fungicides most used are copper sulphate solutions, Bordeaux mixture and ammoniacal carbonate of copper.

Dry Bordeaux Mixture.

During the winter and spring many inquiries as to the value of the dry Bordeaux mixture and methods of manufacture were received, and several parties began its manufacture and put it on the market. Many samples were sent us for

trial, and the results of the tests were carefully noted. As far as can be determined from one season's trial, the results have *not* been satisfactory, for the following reasons: first, that the material is not in sufficiently fine condition; second, that it is impossible to make it adhere for any considerable time to the foliage or other parts of the plants even when applied to a wet surface; third, that there is a great waste of material, much of it falling to the ground. After careful investigation, we have not noticed any marked beneficial result following its use. For the above reasons, the dry Bordeaux mixture does not appear to be as efficient as that in a liquid form.

Steam Spraying Outfit.

One of the greatest obstacles to the use of insect and fungi destroyers has been the difficulty of obtaining pumps of sufficient power to enable the application of liquids to be made thoroughly, as fast as an ordinary team would move along among trees or garden crops; and a careful trial of a steam spraying outfit has been one of the features of the past season's work. As the result of repeated trial, we feel warranted in the assertion that, when run with care and skill, very satisfactory work can be done better and more cheaply than when done by hand or by the gear machines. It is of course understood that the manipulator must be thoroughly acquainted with the construction of the engine and pump, and be skilful in keeping all parts in perfect working order. The cost of such spraying outfits, of which several are now offered in the market, and ranging in price from $200 to $400, is much against its use by the small farmer or fruit grower; but in almost every village or town the work of spraying for a large number of individuals by the single owner of an outfit could be done at a less cost than if each person were to equip himself with small and imperfectly working pumps. This would probably be found more satisfactory than if the outfit were owned by a number of individuals. A steam engine suitable for this work, and fitted with a fly wheel, so that the power could be utilized, when not needed for spraying, for cutting wood, corn fodder or ensilage, grinding grain, pumping water for stock or irrigation, would be a source of profit in many directions.

Seed Testing.

Complaints having been frequently received affecting the germinating qualities of seeds and vegetables and their purity, coupled with requests for examination and testing of the same, an extended investigation was undertaken of seeds of standard varieties from prominent dealers in different sections of the country. In all, 367 different packages of seeds were tested, each variety involving four distinct tests. These were obtained from seven of the leading seed dealers, as follows: 4 from Massachusetts, 1 from New York City, 1 from Philadelphia, Pa., and 1 from Detroit, Mich. The number of varieties tested was: beets, 4 (28 packages);* cabbage, 5 (35 packages); cauliflower, 3 (21 packages); celery, 5 (30 packages); cucumbers, 4 (28 packages); lettuce, 7 (27 packages); melons, 5 (23 packages); onions, 5 (30 packages); parsnips, 9 (18 packages); peas, 4 (28 packages); radishes, 6 (24 packages); spinach, 8 (19 packages); squashes, 4 (28 packages); tomatoes, 4 (28 packages).

These seeds were first tested for their germinating qualities by two different methods under glass. These were also noted when planted in the field, and careful observations made and recorded from time to time as to vigor of growth. At the end of the season the characteristics of foliage and products were carefully determined, and the crop of each strain weighed. Each kind of vegetable was planted in soil best suited to its growth, and the seeds from each dealer given the same treatment in every way.

Results.

We are glad to report that with one or two exceptions the vitality (germinating qualities) of the seeds was very satisfactory, about the same per cent. of seeds of each kind from the different dealers germinating, and the products were generally uniform in outline and markings. The varieties sold by the different dealers under the same name generally proved to possess the same characteristics.

* The same varieties, from 7 different dealers.

With the experience gained in this work the past season it is hoped another year that, in addition to similar tests, seeds may be collected from the stock kept on sale in country stores, much of which is produced by growers of little skill, and possibly in localities where mixing by cross-fertilization cannot be avoided. This will entail a large amount of work, a considerable addition to the area of land occupied and much greater expense.

The complete results of the season's test will be presented in tabulated form in a later bulletin.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

The work of this department has followed the plan outlined in the last annual report. Much of our attention during the past year has been devoted to the study of the gall-forming nematode worms affecting cucumbers and tomatoes grown under glass, in the hope of finding some effectual method of combating them. Professor Smith has devoted considerable attention to the study of their life history. The results of the investigations, when completed, will be published in a bulletin.

Most of the correspondence of the department has had reference to plant diseases, although during the summer many inquiries have been received regarding weeds. For the purpose of facilitating their study, we have collected during the past summer about two hundred and fifty species for the herbarium, including several species which have been recently introduced in grass and other kinds of seed. The department takes this opportunity of soliciting correspondence on this subject, as it is desirous of obtaining information in regard to the introduction and distribution of weeds and other plants which may possibly become troublesome.

The Nature of Plant Diseases.

Before passing on to a consideration of some of the plant diseases which have occupied our attention during the past year, it will be well to pay some attention to the nature of plant diseases in general. The diseases with which botanists have to deal can be divided into two classes, namely: first, those which are caused by parasitic fungi, bacteria and similar organisms; and second, those brought about by purely physiological disorders, which have their origin in some ab-

normal condition of the plant, due to improper care and surroundings. While the distinction between the two classes of disorders can in many cases be readily discerned, in other cases it is indeed difficult to discriminate between them, as physiological disorders of the plant so frequently produce just the conditions which are most favorable for the development of parasitic fungi and bacteria. Thus the original cause of the trouble is liable to be entirely lost sight of. Bearing in mind this fact, it must be clear that to recommend fungicides for the treatment of physiological diseases is about as absurd as it would be for a physician to treat a person for consumption who was suffering from malaria or indigestion, and simply required a change in his food or the conditions which surrounded him. The only logical method of treatment under such circumstances is to restore the normal and proper conditions. On the other hand, parasitic fungi which cause serious disorders in our cultivated plants are also found on plants which would pass for quite normal and healthy ones. In fact, probably no plant is entirely exempt from parasites; and here we are brought face to face with the question, What constitutes a plant disease? It may be defined as a disorder caused by any failing in or diversion of the normal physiological actions of the plant. Practically, we include as plant diseases the effects of all of those forms of parasitic fungi which occur on plants, although it is doubtful whether many of them really cause any perceptible harm to their hosts.

Of the two classes of diseases, the parasitic and physiological, those of the latter are more likely to be prevalent in greenhouse plants, inasmuch as the conditions to which the latter are subjected are very artificial, and cannot coincide very closely with those of their normal habitat. The physiological disorders, moreover, are much less likely to be discerned, and, when found, are more difficult to contend with than parasitic attacks, for they are more complicated in their nature, as well as less thoroughly understood. In all our dealings with the plant we must bear in mind that it is a plastic organism, capable of responding, within certain limits, to a great variety of external factors which act as stimuli. These external stimuli are principally to be found

in heat, light, moisture and in the soil conditions. It is therefore the proper application of these factors which the practical grower has to take into consideration, and his success in plant growing will depend largely upon his skill in dealing with them. The minute details connected with the application of light, heat and moisture, the judicious use of fertilizers and the bringing of the soil into proper mechanical condition, are matters which are now commencing to receive some of the attention which they deserve.

Diseases entirely or partially due to Parasitic Organisms.

A Bacterial Disease of the Strawberry (*Micrococcus* sp.?).

During a hot sultry period which occurred in the month of May, 1895, some diseased strawberry plants of the varieties known as the Sharpless and the Belmont were sent to the botanical department from Fitchburg, Mass., for the purpose of determining the nature of the disease and the remedies for the same. The freshly gathered plants showed by their dark-colored, shrivelled leaves that they had been killed outright in the field by some unknown cause.

A careful microscopic examination of the plant proved that there was nothing of an insect or fungous nature to which the trouble could be attributed; but by making more careful observations of the cell contents of the roots and leaf petioles, numerous bacteria (micrococci) were found, which at least indicated a possible cause of the disease.

At about the same time these specimens were received, the disease made its appearance on many of the strawberry plants in the college plats, resulting fatally to the plants in numerous instances, besides leaving others in a dilapidated condition. The variety which suffered the most in the college plats was the Marshall.

In order to ascertain whether the two diseases were identical, and whether the bacteria were the specific cause of the disorder, the organisms were isolated, and a number of pure cultures made in the ordinary sterilized nutrient gelatine. In this medium the bacteria developed quite readily, producing a white, flocculent mass at the bottom of the tube. Its

manner of growth in gelatine proved it to be of an anærobic * nature. From time to time the organism was transferred to fresh gelatine; and during the next fall three varieties of strawberry plants, including the Marshall, Belmont and Sharpless, were transplanted to the greenhouse. After the new plants, which were not especially robust, had made some growth, they were placed in a warm, humid atmosphere, and the roots of a number of plants of each variety were inoculated with the pure cultures of bacteria from the gelatine tubes. As a result of the inoculation, the plants after a few days showed the effects of the disease, some, however, more than others; but in all cases the disease was somewhat milder than in the plants originally affected. An examination of the affected parts of the plant showed the same bacterium, and cultures made from the petioles and roots gave the same characteristic micrococci. Other strawberry plants were again inoculated with the new isolated forms, with corresponding results.

No further experiments in this direction were considered necessary, inasmuch as the effects of the bacteria upon the plants had been ascertained. I will state here, however, that I had never seen the disease previous to this, neither have I been able to detect it since. I consider it one of those sporadic afflictions with which any plant is likely to be troubled, provided just the right conditions are at hand. In this instance the conditions of the weather and that of the plant were especially favorable for such an attack. All of the plants under examination were young, and had not been transplanted a great while; and, furthermore, they had all the appearances of plants which had not become firmly established in the soil. The organism is, not unlikely, a common form of micrococcus which under peculiar conditions is liable to cause some injury. Inasmuch as the primary cause of the disease has its origin in a weakened condition of the plant, and inasmuch as there is every reason to believe that the organism gains its entrance through the root, any attempt to apply fungicides would be useless. The only practical method of dealing with a difficulty of this kind, should it occasionally make its appearance, is to take more pains in

* Not requiring free oxygen.

securing a rugged stock and to keep a more watchful care over the plants during their critical period of transplanting, thus rendering them less susceptible.

A Stem Rot of the Cultivated Aster.

My attention was first called to this disease during the fall of 1895, while visiting the florist, Mr. L. W. Goodell of Pansy Park, who raises a large variety of asters for seed. The specimens obtained from Mr. Goodell were gathered rather late in the fall, when the disease was far advanced, being characterized at this stage of its development by a general blackened and shrivelled condition of the whole plant. Closer observation of the specimen, however, located the point of attack on the stem, close to the root, where the epidermal tissues which surrounded the abnormally hardened wood were more or less disintegrated.

A microscopic examination of the tissues of the affected parts showed a variety of organisms, such as bacteria (micrococci), nematode worms, and such mould-like fungi as Alternaria, Macrosporium and Physarium. Some of these organisms alone might give rise to the disease, but it is more probable that most of them were merely accompanying factors of the diseased conditions to which the plants were subjected.

The bacteria and nematode worms were by far the most abundant, the bacteria especially being widely distributed through the tissues, on that part of the stem adjacent to the roots. Owing to the fact that all of the material at our disposal was in too advanced a stage, it was impossible to arrive at any definite conclusion in regard to the cause of the disease. Since examining the specimen obtained from Mr. Goodell we have heard of the disease as occurring in other places. Among them may be mentioned Mr. Joseph Ammer of Springfield, who writes us as follows: —

DEAR SIR: — In reply to your favor of September 21, I am sorry to say that I cannot send you a specimen of the aster plants, because they are all past. The plants appeared to be in a good and vigorous condition up to the time of setting flower beds, when they began to wilt very rapidly, and in a little more than a week a whole bed of seventy-five or one hundred plants was nearly if not

quite gone, save perhaps eight or ten. On closer examination I found that the stock right at the surface of the soil for about an inch appeared, soft and pulpy and could be scraped away to the hard heart, which in most cases was black and dead. I could not account for it in any way, unless it was some fungous disease.

There are many others around here who are troubled the same way; some called it lice on the roots, others "aster blight," and let it go at that. The varieties most affected were "Queen of the Market," "Victoria" and the "Comet," while the new "Giant White Comet" was entirely free from it, although separated from the worst bed only by a four-foot path.

If you can suggest any treatment, I should be glad to try it another year, for I dislike to be obliged to give up growing asters, but will have to unless some remedy can be found for the trouble.*

The disease is one that requires further investigation, especially in the field near greenhouses where the asters are grown, in order that the first stages can be more closely observed. The cause of the disease is not unlikely due to some improper method of cultivation; at all events, it is not desirable to recommend any method of treatment until more is known about it. In one instance, when the plants were badly affected in 1895, they were raised in a new field the following season, with the same disastrous results.

In this connection we wish to state that Professor Smith observed some aster plants in a small bed last summer quite similarly affected, but in this instance the death of the plants was undoubtedly caused by a small grub which devoured the roots.

"*Leaf Spot*" *of Decorative Plants.*

We use here the term "decorative" in a special and limited sense, as it is ordinarily used by florists, meaning to include such plants as palms, Dracænas, Ficuses, etc., which are used mostly or entirely for the ornamental effect of the plant as a whole, and this on account of the leaves. Specimens of such plants may be found in almost any florist's establishment, the leaves of which are more or less "spotted;" that is, certain portions of the leaf are dead and withered,

* We attempted to obtain specimens of diseased plants from the Springfield growers, but unfortunately it was so late in the season when the disease was reported from this locality that we were unable to do so, as the affected plants had been destroyed.

and contrast prominently with the surrounding green tissues. Sometimes all the leaves on the plant are affected; again, only a few show any spotting. Sometimes almost the entire leaf is dead; in other cases, only a small spot. Such plants, if at all seriously affected, are of course almost valueless for decorative purposes, and even in less serious cases their beauty is greatly impaired; consequently it is well worth an effort to get rid of such disfigurations, and prevent their reappearance. In order to do this, we must first know the cause or causes of the difficulty. They are extremely various. Any injury, or weakening of the vitality of the plant in any way may produce the effect indicated by the well-known expression "leaf spot." It may be nothing more than a simple burn, produced by the sun's rays concentrated in passing through the glass roof and drops of water on the leaves, or, as frequently happens, by contact of the leaves with the heating pipes. The attacks of insects also sometimes have quite a similar effect. But the trouble is not always so obvious. Various other agencies conspire to produce the effect which we are considering.

It may be stated, as a general principle, that the healthy and rapidly growing plant is the least likely to fall a prey to disease. Exceptions to this may be found in the case of unusually vigorous outbreaks of the most destructive diseases, but in the long run the rule holds good. Let the plant become weak and sickly from improper and insufficient nourishment, too much or too little heat, light, water, etc., poor ventilation or drainage, or any other disturbance of its normal functions, and its liability to disease becomes largely increased. At such a time the weakening of the plant's vitality may proceed so far as to cause a gradual dying away of the leaves and thus produce spotting, or it may, and always does, favor the attacks of parasitic vegetable organisms, most of which belong to the class called the fungi. Such attacks, together with those of bacteria and other vegetable organisms of low rank, are alone properly considered as plant diseases. The fungi are true plants, but of low order and microscopic in size. Some of them are strictly parasites, *i.e.*, they can live only upon the tissues of other organisms. Others, like the toad-stools, are strictly saprophytes, *i.e.*, they live only

upon dead and decaying organic matter. These are entirely harmless to plant life. Still others, while ordinarily saprophytes, have parasitic tendencies, and may attack plants in a weak and unhealthy condition. A sickly or injured plant may be attacked by a variety of such forms, together with true parasites, bacteria, insects and other organisms both of the animal and vegetable kingdoms, making it impossible to say which was the original cause of the trouble, if, indeed, any one of them could be strictly considered as such.

A leaf spot produced by fungi is a place on the leaf where a fungous plant has become established and consumed the vital substance. The spot becomes larger as the fungus grows out into new tissue. Fungi reproduce themselves by *spores*, corresponding to the seeds of higher plants. These spores are of course extremely minute, and are produced in infinite numbers. They are smaller than the finest dust, and float about in the air with the greatest readiness.

In the treatment of fungous diseases only one course of action can be successful. This is *prevention*. A leaf once infested with a fungus can never be restored to its normal condition, for not only is the fungus within its tissues and out of reach of any treatment, but, furthermore, certain parts of the leaf are already dead, and can never be restored. One method of preventing such diseases is by killing the spores before they can germinate. The now common operation of *spraying* consists in applying to plants affected or liable to be affected by disease certain substances diluted with water to a strength sufficient to destroy the fungous spores but not injure the leaves. This solution is applied in the form of a fine spray, by means of a pump and nozzle. The application of this method is now well established in the treatment of most of our destructive plant diseases, especially those affecting fruits and vegetables. The most effective substance thus far discovered for spraying purposes is the so-called Bordeaux mixture, — a sort of blue whitewash, made by combining lime with copper sulphate (blue stone, blue vitriol). Many other substances have been tried, some with great success; but the Bordeaux mixture is still the most satisfactory for general purposes, for it kills the spores, sticks to the leaves and does not injure the plant.

But in the case of decorative plants, even if the Bordeaux mixture effectually prevented disease, its use would involve a serious disadvantage. Imagine a fine palm or Ficus covered with blue whitewash! It would certainly be more disfigured than by any disease. We have, however, other fungicides which have given very satisfactory results in the treatment of plant diseases, and which, being clear solutions, leave no stain on the plant. Among these the so-called ammoniacal copper carbonate solution is one of the best. It is prepared by dissolving one ounce copper carbonate in strong ammonia (26°), of which about one pint will be required. The copper carbonate should be put into a wooden pail with sufficient water to make a thick paste, and the ammonia then added. The resulting solution is then diluted with about nine gallons of water.

But, aside from any method of spraying, much can be done for the eradication of spot diseases by removing and destroying all affected leaves, etc. This must be done promptly and thoroughly, in order to be effectual. As soon as a leaf is seen to be spotted, it should be removed and *burned.* This will certainly lessen the extent of the disease, and will in many cases entirely eradicate it, if the plant be kept in good growing condition. We would recommend, however, that all plants which have been or are liable to be attacked by such diseases should be sprayed with the above-described solution, the frequency of the operation varying with circumstances. A plant which has been diseased should be sprayed three or four times, at intervals of about two weeks. If then no further indications of the disease appear, spraying may be discontinued altogether, or the whole house may be thoroughly wet down with the solution every month or two, as a general precaution. (If the house contains any particularly delicate or valuable plants, it may be well to try the solution on a small scale on them before applying it generally. We have experimented with quite a variety of common greenhouse plants, and have experienced no harmful results. The solution should be diluted to the full extent recommended.) Spraying apparatus can be obtained of any dealer in agricultural implements.

But, after all, the perfection of spraying methods, however

successful, is not the *ne plus ultra* of the science of growing plants. We would not in the least disparage the most exceedingly valuable results of the work done by experiment station workers and others in this direction. There can be not the slightest doubt that millions of dollars' worth of fruit and vegetables have been and will continue to be saved from destruction by this means. But the fact remains that success in growing plants, as in every other direction of human industry, comes not from the observance of any laid down rules and formulas, but rather is the reward of long experience, close application and intelligent skill. The triumph of the gardener's art is the plant brought to perfection in a natural, normal and healthy manner, and not that which owes its existence to skill in doctoring.

We will now briefly describe a few leaf-spot diseases which have come to our notice and which have received little or no public mention. The treatment which we have recommended will apply of course to these and any other similar diseases.

A Leaf Spot on Ficus elastica (India Rubber Plant).

(*Leptostromella elastica*, Ell. and Ev.).

The rubber plant, which is used quite extensively for ornamental purposes, on account of its large, dark-green leaves, is not often attacked by disease. In our own houses and also in other places in this State we have, however, recently found plants affected by a serious spotting of the leaves. The first indication of the disease is seen in the leaf's turning in small spots or streaks, which rapidly increase in extent, changing from yellow to a brownish color and finally to an ashy gray, when the affected portion is quite dead. At this stage the spots may include a large portion of the leaf or only a small part of it. There is often more than one on a leaf, but never a large number. The dead portion is sharply distinct from the living, and banded by a narrow black margin. Upon its surface little black dots appear, which are cavities containing the spores. The spots keep increasing in extent, until the leaf finally loses its vitality and falls from the plant. No plant more than ficus shows the effect of such a disease as this, since its handsome, dark-green leaves are its only ornamental feature.

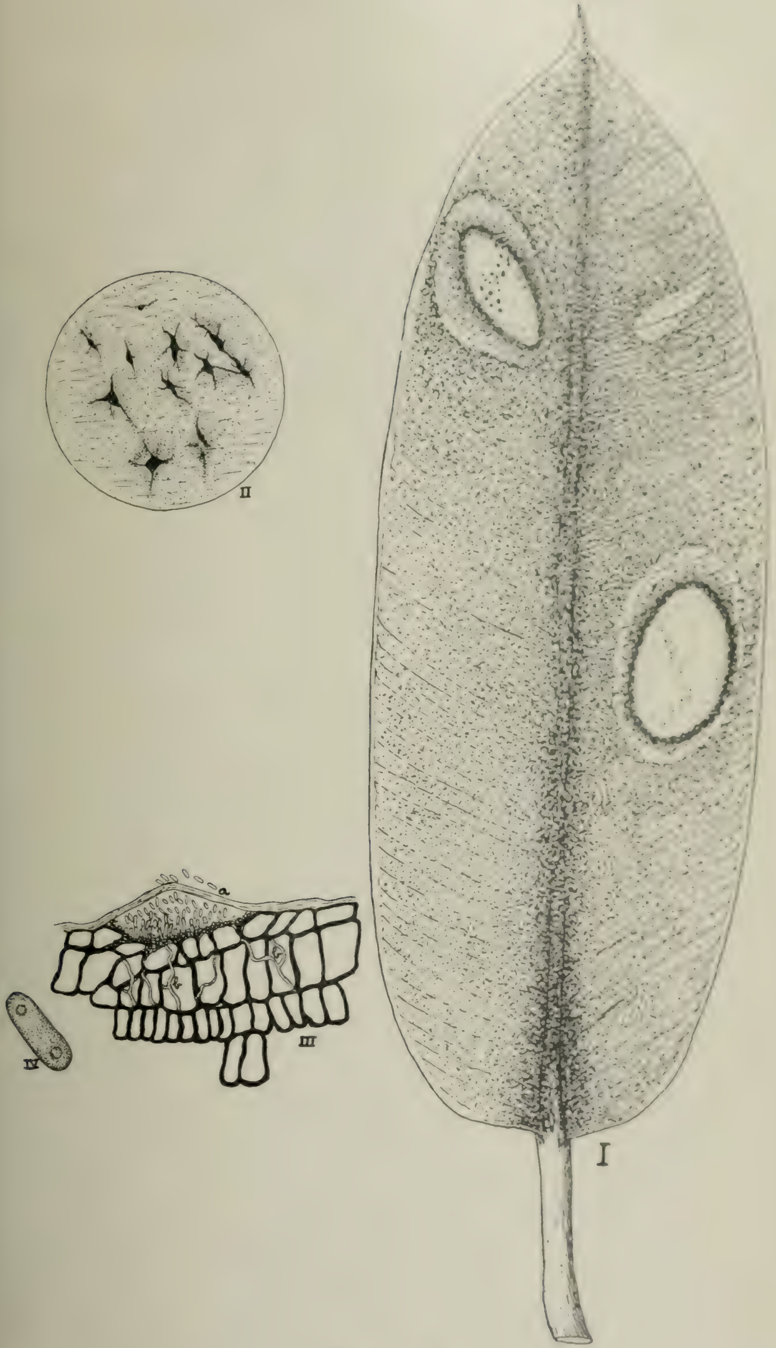

Figure 1.

I. Leaf of Ficus Elastica with spots caused by *Leptostromella Ela*[illegible]

II. Surface of dead area enlarged, showing spore bearing cavities.

III. Cross section of dead area with spore cavity at *a* and filaments *b*, running among the cells of the leaf.

IV. A spore x 1300.

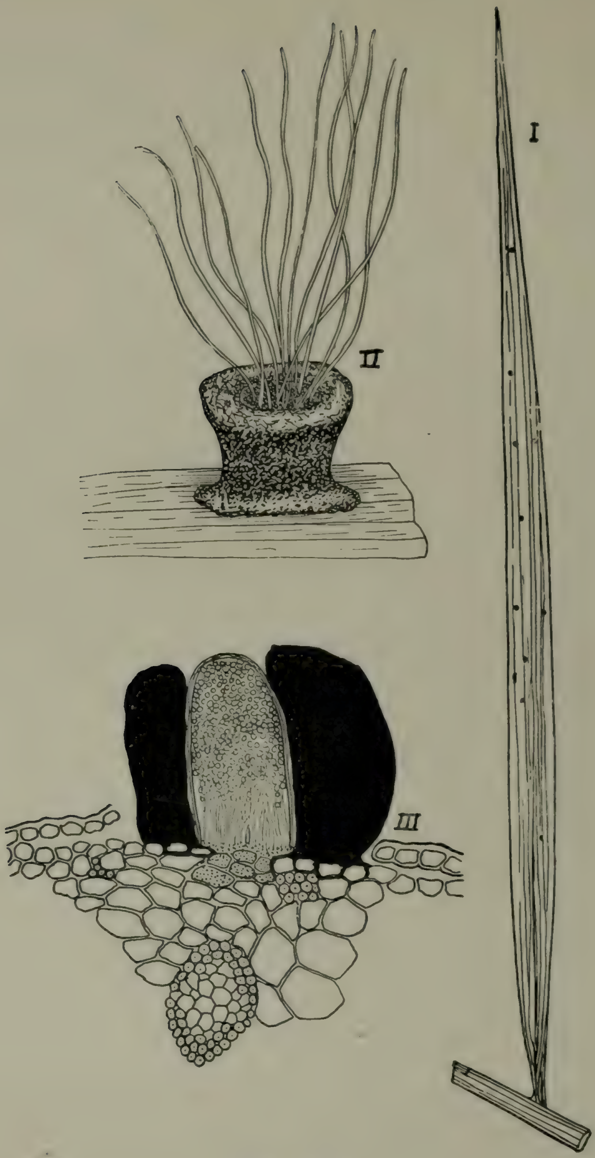

Figure 2.

I. Leaf of Phornix Canariensis attacked by *Graphiola Phornicis.*

II. Spore bearing conceptacle enlarged.

III. Section of a conceptacle full of spore, and portion of the leaf.

This disease was first brought to notice by Prof. F. L. Scribner, in "Orchard and Garden," January, 1891, and scientifically described at about the same time by Mr. J. B. Ellis, from specimens sent by Professor Scribner. We find no mention of it since that time, which seems to indicate that it is not generally prevalent. Should it become so, it cannot fail to become very troublesome, for it spreads with considerable rapidity, and has a ruinous effect upon the decorative value of the plant. It was introduced into our houses, apparently, on a variegated-leaved Ficus elastica purchased from an outside florist. From this plant it spread to others of the ordinary green-leaved type, and has practically ruined several fine specimens. Great care should therefore be taken, in purchasing stock outside, that it be free from disease. (Not infrequently we hear of Ficus plants whose leaves turn yellow and drop off. This marks the normal end of the existence of the leaf, or, if it occurs extensively, an unhealthy condition of the plant, and is not to be confused with the fungous disease. An effect almost exactly similar, superficially, to that of the latter, is sometimes produced by sunburn.)

A Leaf-spot Disease of the Date and Similar Palms (*Phœnix* sp.).

(*Graphiola Phœnicis*, Poit.)

This disease is by no means a new or unknown one, but it has received little attention from an economic stand-point. It attacks various species of Phœnix in cultivation, and injures and disfigures them to a considerable extent. The affected parts of the leaf become mottled with yellow, and upon the surface little black eruptions appear, which are cup-shaped conceptacles produced by the filaments in the interior of the leaf, and in which the spores of the fungus are produced. These little eruptions are about one-fiftieth of an inch high and twice as wide, — plainly visible, therefore, to the eye. They consist of a firm, dark-colored exterior layer, enclosing a more delicate inner covering, which contains a mass of thread-like filaments on which the spores are produced. The leaf becomes thickly dotted over on both sides with the conceptacles and slowly shrivels away and

dies, innumerable spores being produced meantime, which are ready to attack new leaves and plants. A fair-sized plant of Phœnix canariensis, sent in for examination and treatment, was found to be badly affected with this disease, and was treated as recommended above. All leaves which showed any sign of the disease (which included all the larger leaves of the plant) were cut off at the base. The plant was then sprayed, and has since developed new leaves which show no sign of the disease, though it is now nearly a year since the plant was received.

A Leaf-spot of the Begonia.

While it may be questioned whether the value of the begonia is strictly that of a decorative plant, in the sense in which we have been using this term, still, it cannot be denied that the plant is often used for this purpose, and on that ground we will consider in this category a spotting of its leaves which has come to our notice. Ordinarily the begonia is seldom affected by disease, insects or any other injurious agency. Still, it is not invulnerable, and we find occasional reports of diseased plants. In the English journals, "The Garden" and "The Gardener's Chronicle," a discussion runs along through several numbers in 1895, concerning a so-called "begonia rust," which seriously affected tuberous begonias. This, however, was finally settled on good authority to be insect work. "Damping off," a fungous disease of begonia and many other kinds of seedlings, is not uncommon. Professor Halsted of the New Jersey Agricultural Experiment Station mentions two leaf-spot diseases of begonia in the "American Florist," September, 1894, one caused by nematode worms, the other a fungous disease.

During the past year or two we have met with a definite spot disease on begonias, mostly of the tuberous variety, which is quite prevalent in our houses and those of a neighboring florist. We are not yet entirely certain as to the cause of the difficulty. The spot begins either on the margin or interior of the leaf, and slowly increases in size until the leaf dies and drops off. There are sometimes several spots on each leaf. As they increase in size their surface is

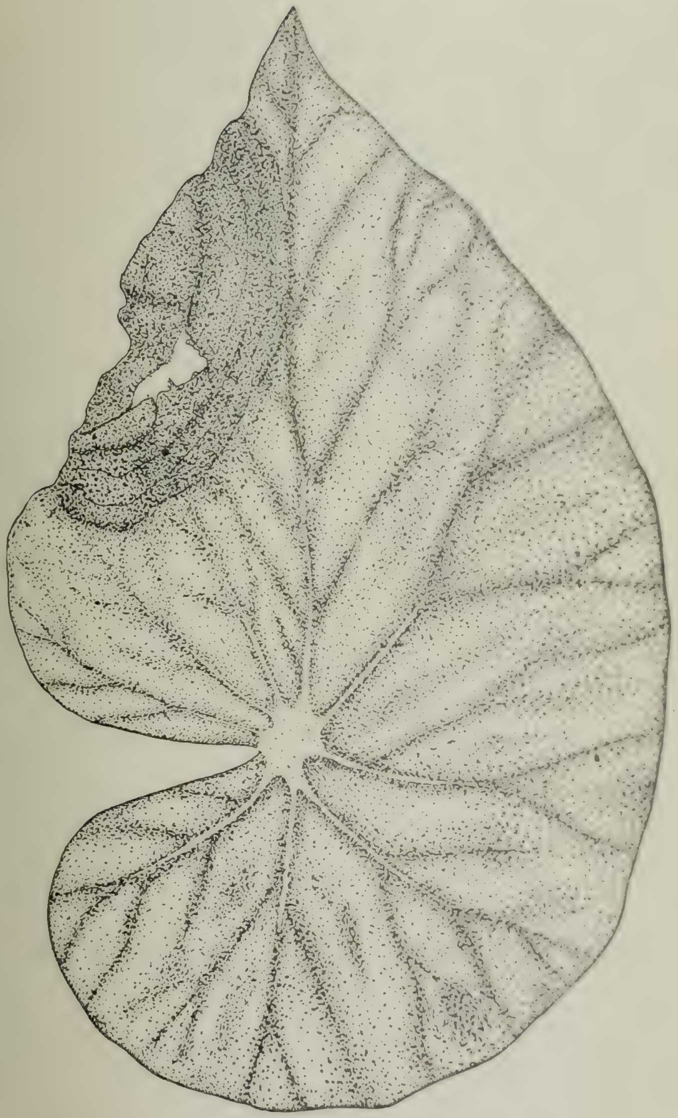

Figure 3. — Spotted Begonia leaf.

marked by concentric curved lines parallel to the edge of the dead portion, as in many spot diseases of fungous origin. Microscopic examination, however, shows nothing which may with certainty be decided upon as the cause of the trouble. We usually find fungous filaments and spores, but they are of many different species, and mostly moulds of a saprophytic or only partially parasitic nature, and cannot be regarded as the primary cause of the disease. In a few specimens we have found the spore-bearing conceptacles and spores of a fungus belonging to or near the extensive parasitic genus Glœosporium, which includes a great number of leaf spots. We consider this as the probable cause of the disease, but the spore-bearing material was very scanty, and we were unable to identify it with any described species. Possibly the trouble may be due to various causes, not all of a fungus nature, but appearances seem to indicate that there is a definite disease which causes most of the spotting. At all events, it will be a wise precaution, in this and all similar cases, to remove and burn all affected leaves.

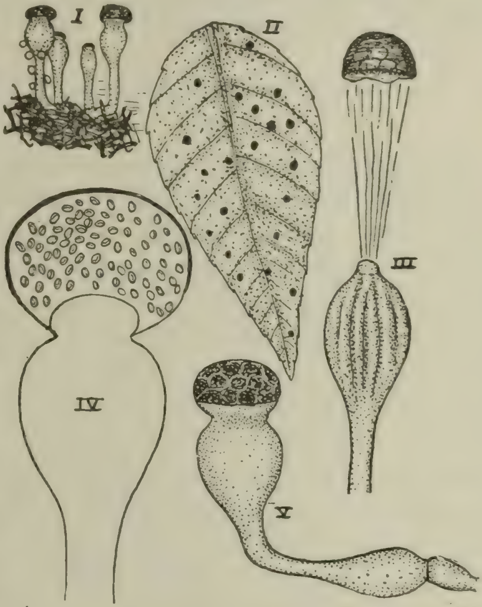

Fig. 4.—Pilobolus crystallinus, Tode.

I. Somewhat enlarged.
II. Sporangia on rose leaflet.
III. Discharge of sporangium.
IV. Section of sporangium and filament, showing spores.
V. Sporangium upon filament before being discharged.
III., IV. and V. are greatly enlarged.

Several other leaf spots of the palm, dracæna, ficus and other decorative plants have come to our notice. Some were only simple sun-burns, while others were real fungous diseases. What was at first thought to be Leptostromella elastica (the above-described leaf spot on Ficus elastica)

upon Ficus religiosus, the banyan tree, proved to be simply a sun-burn, though its superficial resemblance to the fungous disease was most perfect. Quite a serious and apparently new spot disease of greenhouse orange trees has been met with, which is of true fungous origin. It is not necessary to describe all these forms in detail, as the treatment is practically the same in each case.

A So-called Black Spot of the Rose.

(*Plilobolus crystallinus*, Tode.)

It is not unusual to find rose bushes in the greenhouse thickly dotted over with little black specks, appearing not unlike "fly specks," which occur on all parts of the plants alike, and of course greatly disfigures the blossoms. Microscopic examination shows each speck to be a minute sac, filled with what are evidently fungous spores. It would thus appear that we had here a fungous disease, and as such it has been described under several different names. In fact, however, this is in no sense a disease, and the little sacs of spores have no real connection with the rose plant, being attached to it simply by cohesion. The sacs of spores or *sporangia* are produced by a fungus, Pilobolus crystallinus, which is strictly saprophytic, and grows on decaying manure. As such manure is usually placed upon the soil under roses, spores of the Pilobolus are introduced in it, and find a favorable place for development. They produce the thread-like filaments which make up a fungous plant, and on the ends of certain of them sporangia are developed. The filament behind each sporangium becomes filled with a watery fluid, which gradually increases in quantity, and exerts a pressure on the sporangium at the end. This pressure becomes so great that finally the sporangium, ât about the time of its maturity, is forced from the end of the filament with sufficient power to send it a considerable distance. We have seen them on the roof of a rose house at least eight or ten feet from the soil where they were produced. Striking a plant, they adhere to it, and give the appearance of having developed there. We find them particularly on the rose, simply because the practice of covering the soil with manure is confined to the cultivation of that plant.

While this is not a disease in any sense of the word, still, the effect of the fungus on roses is of course disastrous to their beauty and salability. Knowing that the disfiguring sporangia come from the manure, where they can readily be seen in the morning in process of development, it would seem a comparatively simple matter to destroy them at that stage, either by mechanical means or by spraying with a fungicide.

A Leaf Blight or Anthracnose of the Cucumber.

(*Colletotrichum Lagenarium* (Pass.), E. and Hals.)

During the past summer we have received specimens of cucumber leaves from several different parts of the State, which were infested with a very destructive blight. In Arlington and Leominster, where the raising of hot-house cucumbers is carried on extensively, the disease was reported as doing great damage. The fungus which causes this trouble grows within the tissues of the leaf, and by sapping its vitality causes its death. Under favorable conditions it is very quick acting and extremely destructive. The infested leaf first shows yellowish spots upon its surface, which rapidly increase in size and become dry and dead. Various moulds often develop upon the dead areas, and, being more prominent than the fungus which really produces the disease, appear to be the cause of the trouble. A dark-brown, luxuriantly growing species of Macrosporium or Alternaria was particularly abundant upon the specimens received this summer, and had evidently been taken to be the cause of the disease, which was referred to as the "brown mildew," "brown leaf blight," etc. Such growths undoubtedly hasten the destruction of the leaf, but they are able to develop only upon leaf tissue which has been killed or greatly weakened by the other more strictly parasitic fungus which is invisible to the eye. The dead areas gradually fall away, leaving large irregular holes in the leaf, which in a short time becomes entirely dead. The same fungus often attacks the fruit, causing it to rot badly, and has been proven to be the cause of the well-known "rust," so called, of the pods and leaves of the bean. It also attacks the watermelon, musk-melon, citron, squash and pumpkin, affecting both leaves and fruit. We have recommended spraying every week or two with the

Bordeaux mixture for this and one or two other somewhat similar cucumber diseases, and have received reports from Arlington of favorable results from such treatment. While this is a most destructive disease if left unchecked, it ought nevertheless to be kept under control with comparative ease if judicious spraying with any good fungicide be combined with proper management of the crop.

An Unusual Outbreak of Two Rusts.

The Asparagus Rust (*Puccinia asparagi*, D. C.).

The rust of the asparagus has been known in Europe for more than half a century, and has caused more or less damage there. In this country it has been known for several years, but not at all extensively. During the present season, however, asparagus beds in various parts of this State, in New Jersey and doubtless in other States, have been seriously attacked by this rust, and are threatened with great injury should it continue to develop extensively from year to year. This fungus is one of the true rusts, and is quite similar to that attacking the wheat. Like it, there are three distinct stages of development, in each of which a different kind of spore is produced. According to European accounts, the rust first appears on the asparagus in the spring, at which time it produces the first kind of spores, the *æcidia*. These develop in turn during the summer, and produce the spores of the second or red-rust stage, the *uredo* spores. These again develop, and produce spores of the third or black-rust stage, the *teleuto* spores, which lie over winter and in the

FIG. 5. — Section of a cluster of teleuto spores of *P.* asparagi, greatly enlarged.

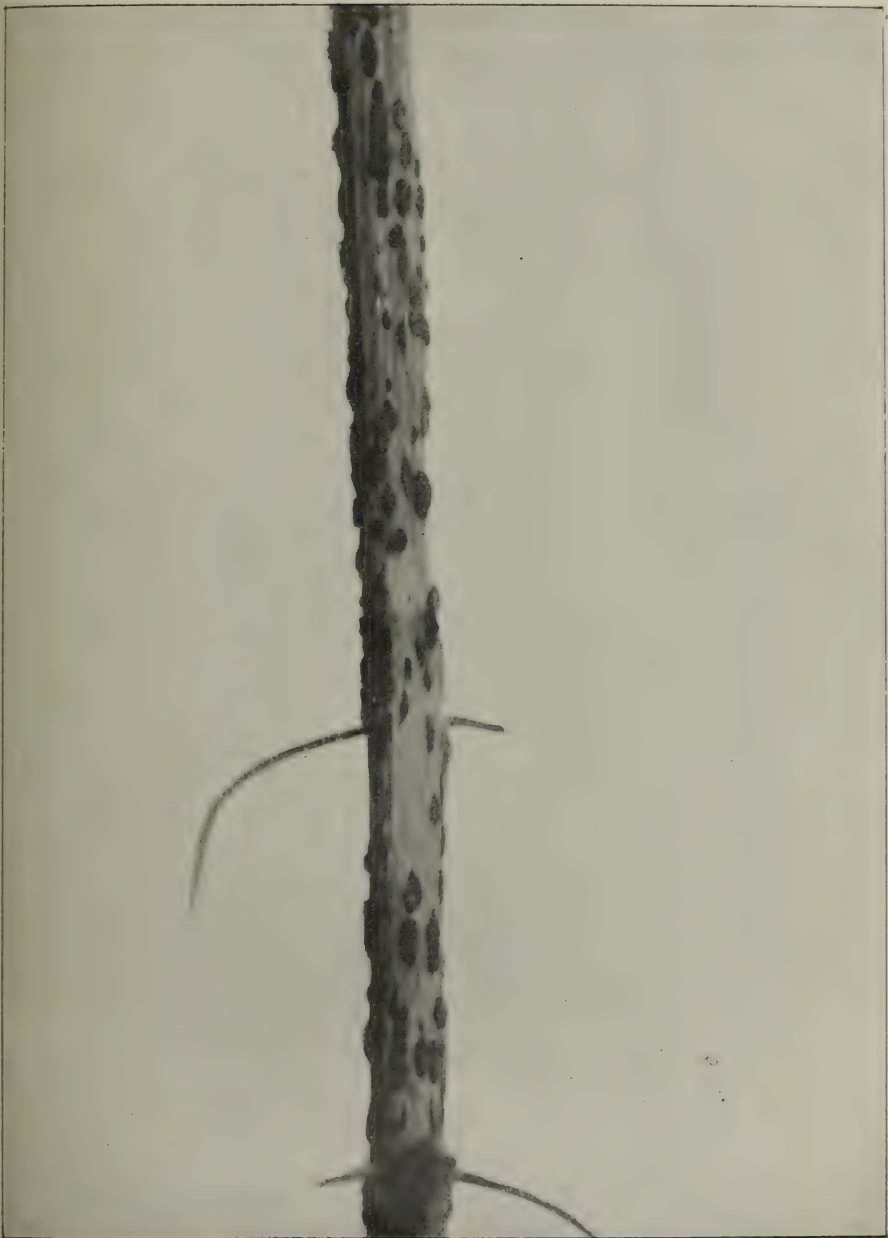

Figure 6.—Asparagus stem with rust.

spring attack the asparagus again, and produce æcidia. In each stage the fungus consists of minute filaments, which grow in the tissue of the plant and draw their nourishment therefrom. In some rusts one of the stages is most prominent, in others it is another. In the wheat rust the uredo or red-rust stage is perhaps the most conspicuous. In the present case the black or teleuto spores are most prominent. They appear in October and November, when the affected plant becomes thickly covered over with small, irregular black lines and blotches, which are the masses of spores pushing out through the surface. This is the stage which has been observed this fall in Massachusetts and New Jersey. Doubtless the other two stages were developed during the season, but did not become sufficiently prominent to attract attention.

Since this disease does not become prominent until late in the fall, and the asparagus crop is gathered in May and June, a question naturally arises as to how it can have any serious effect. There is indeed no great danger to be apprehended of its actually disfiguring the marketable product; but no plant can undergo a continuous and vigorous attack of a parasitic fungus without a serious loss of vitality, if it be not killed outright. If this rust appears only intermittently and not extensively, its ravages need not be seriously feared; but, should it continue to develop in the present abundance year after year for any considerable time, it cannot fail to become a most serious obstacle to the raising of asparagus. Moreover, we have examples in similar rusts, like that of the hollyhock upon its first appearance in Europe and later in this country, which have developed with unusual vigor and destructiveness immediately after their first outbreak in a new locality and climate. The raising of hollyhocks in Europe was well-nigh impossible for some time after the introduction of the rust. The progress of this asparagus rust is therefore worthy of close attention and some apprehension. Meantime, attempts should be made to check it as much as possible by cleaning up the bed in the fall and burning the infested tops, thus destroying countless numbers of spores. This should be done as early as possible, before the spores shall have become mature and scattered by the wind.

A Late Rust of the Blackberry (*Chrysomyxa albida, Kühn*).

This rust, like that of the asparagus, has been long known in Europe, but only comparatively recently observed in this country. It was first brought to attention in America in 1886, but, while it has been not uncommon since then, it has never assumed any economic importance. Very likely it has been more or less confused with the spring orange rust (Cæoma luminatum, Lk.), which it slightly resembles, and on that account has escaped particular mention; still, it is hardly probable that it has been generally prevalent. In the season of 1894, however, it became decidedly abundant in our plantations, and caused considerable apprehension. It was also reported from other parts of the State, and threatened to become a serious matter. In 1895 it appeared again, but not so abundantly as in the previous season; and this year its attacks have been very slight, so that there seems to be no ground for fear of danger from this source at present.

Description. — This has been called the *fall* rust, to distinguish it from the *spring* rust, which appears much earlier in the season, and is entirely distinct. The latter is a well-known disease to fruit growers, as it causes much damage and has been the subject of many experiments and published articles. It attacks both blackberries and raspberries. Chrysomyxa albida comes on later, appearing in August and continuing through the fall. It does not attack the raspberry. It is one of the true rusts, having the three kinds of spores, as in the asparagus rust. In this case, however, it is the æcidia and uredo spores which are most prominent. These appear in small, powdery, scattered, bright orange-red spots on the under side of the leaf, and are consequently not as prominent as the indications of the asparagus rust.

While the same conclusions as to the future may be drawn in this case as in that of Puccinia asparagi, still, the results of three years' observation on the blackberry rust indicate that we have no great cause for alarm in that direction; while in the other case, having no such definite knowledge, we cannot but feel somewhat apprehensive until time shall show what is to be the result.

The Tomato Mildew (*Cladosporium fulvum*, Cke.).

The disease which is commonly called mildew is without doubt one of the greatest obstacles to success in growing tomatoes in the hot-house. While it does not always kill the vines outright, still, its effect in weakening their vitality and reducing their yield is a most serious one. We have received specimens of tomato leaves affected by this disease from several different localities, and have observed it in greater or less abundance in almost every house of tomatoes which we have examined. It also attacks tomatoes grown out of doors, but by no means so generally as in the hot-house.

When this disease comes on, there appear on the lower surface of the leaves brownish, felt-like spots of irregular shape and various sizes, which rapidly increase in extent, until the whole leaf finally turns black and withers away. It does not always spread so rapidly and kill the leaves at once, but is often found only on the lower leaves, or in spots which do not increase rapidly in size. Nevertheless, it is constantly weakening the plant, and, let a favorable opportunity come, as come it will sooner or later, and it spreads through the house with great rapidity and destructiveness.

The fungus consists of a dense mass of thread-like filaments, which ramify through the leaf in all directions and more or less upon its surface. The felt-like areas on the under surface of the leaves are composed of a mass of spores and the filaments which produce them. The spores germinate readily in water, developing filaments similar to those from which they were derived. This species belongs to a group of fungi which are mostly moulds and mould-like forms, growing upon dead vegetable matter or plants in a weak and unhealthy condition. This mildew is especially active in attacking such plants, upon which it produces the above-described disastrous effect. Its development is also greatly favored by excessive moisture in the air, *i. e.*, a "muggy" atmosphere, which indeed is favorable to the development of most plant diseases. The tomato requires a considerable heat for successful growth in the hot-house. If, while the plants are growing rapidly, the temperature

suddenly falls from any cause and they consequently receive a check in their growth, it will be a most favorable time for an attack of the ever-ready enemy, the mildew. Poor ventilation and partial exclusion of sunlight by crowding the vines too close together will produce a muggy atmosphere, and have a similar result. To prevent crowding, it is advisable to trim up the vines somewhat and train them to trellises or single stakes. Uniform heat, good ventilation and free access of air and sunlight to all parts of the plant will prove the most effective preventive of mildew. In our climate, however, the first two conditions are liable to prove antagonistic to each other; for in cold, windy weather it is impossible to ventilate the house without greatly reducing the temperature.

Spraying with the ordinary fungicides has proved effectual in preventing this disease. The spraying should be done about once in two weeks, commencing when the plants are quite small. It is also a wise precaution in all hot-house work to thoroughly clean up and burn all dead leaves, vines and similar materials when a crop is removed, and, if possible, fumigate the house with sulphur. The latter of course cannot be done if there are any plants growing in the house.

Too often we find that such diseases as this are allowed to develope in the house, with no effort being made to check them. So long as the plants are not killed outright, many growers seem to think that no damage is done. This is certainly not the case, for the presence of the fungus is a constant drain upon the vitality of the plant, reducing its yield both in quantity and quality. The practice of spraying, which can be done at an insignificant cost per plant, will, if properly carried out, prove both effectual and profitable.

A Crysanthemum Rust.

Specimens of diseased chrysanthemum leaves which have been sent in to the station for examination prove to be affected with one of the true rusts, the first, so far as we know, to be reported upon this host. The specimens were sent by Mr. Geo. H. Hastings of Fitchburg, Mass., who writes as follows: —

The "rust" is quite common on the chrysanthemum leaves. In the advanced stages it completely kills the leaf. It seems to me that it is a very bad enemy to fight. I had plants enough to bring seventy-five or a hundred dollars worth of flowers, and I would not sell one flower, as I did not wish to have the name of selling such flowers. The plants were grown in the garden and "lifted" about the middle of September. The rust was on the leaves at that time, and some of them were dead.

The rust was in the uredo or red-rust stage, and proved to be a form closely resembling and probably identical with Puccinia Tanaceti, S. (P. Helianthi, D. C.), which occurs commonly upon Tanacetum vulgare (tansy), several species of Artemisia (ragweed) and Helianthus (sunflower), and several other related plants. Upon these plants it sometimes acts most destructively, as it has done in this instance upon the chrysanthemum. It bids fair to become a serious obstacle to the cultivation of this valuable flower.

Experience has shown that in the development by cultivation of any plant, as it becomes changed more and more from its natural form and forced into an abnormal development, its power to resist the attacks of disease becomes diminished. For this reason reports of new diseases upon our various cultivated plants are of frequent occurrence. All such diseases are certainly not new in the sense of being caused by a kind of organism which never existed before, but only new upon some particular kind of plant, which has, by reason of its forced and abnormal development, lost the power to resist the attacks of the parasite, which has existed all along upon some other kind of plant, and very likely in a milder form.

The chrysanthemum in its present form is a comparatively new plant in this country. Its great popularity has led growers to make extraordinary efforts to force its development along certain lines, notably in size of flowers. The production of flowers eight inches in diameter by a plant destined by nature to produce them less than quarter that size cannot be accomplished without bringing about serious changes in the vital functions of the plant, and making it more susceptible to disease. Therefore the list of chrysanthemum diseases may be expected to gradually increase, as

it is now doing. At least two have been previously known. *The leaf spot* (Septoria sp. and Phyllostica sp.) was first described by Professor Halsted of the New Jersey Experiment Station several years ago, and occasions more or less damage. *The mildew* (Erysiphe Cichoracearum D. C.) has appeared more recently, and is rapidly increasing. This has a history very similar to that of the rust under consideration, being very common on Helianthus and Artemisia, as well as many other plants.

We can make no definite recommendations at present as to a treatment for this rust, it having been reported so late in the year. The true rusts are notoriously difficult to combat; the most so, perhaps, of any class of diseases. Many methods of treatment have been tried, but few with decisively profitable results. That panacea of plant diseases, the Bordeaux mixture, has been frequently recommended and tried for various rusts, with widely varying results. The same can be said of another common fungicide, the ammoniacal copper carbonate. Stewart, of the New York Experiment Station, reports, in the case of the carnation rust (Uromyces Caryophyllinus (Schrank) Schrt.), that a solution of potassium sulphide, one ounce to one gallon of water, was most effective. This strength might injure chrysanthemum leaves. One ounce to four or five gallons of water would be safer, but not, of course, as effective. With the hollyhock rust (Puccinia Malvacearum, Mont.), a very destructive disease, Mr. H. L. Frost of Arlington informs us that he has tried the Bordeaux mixture and also the commercial fungicide called "Fostite," with results in favor of the latter. It is possible, then, that some of these substances may be effective in preventing this chrysanthemum rust, but we cannot vouch for it. It would certainly be advisable to spray the plants occasionally with the Bordeaux mixture or with potassium sulphide, *commencing in the summer, when they are young and before any disease appears.* If the plants are healthy when put into the house, one or two sprayings thereafter should be sufficient to carry them through the season. All plants known to be diseased should be removed and burned.

We would urge any grower who has been troubled with

any disease of his chrysanthemums to carry on a series of experiments with various fungicides, in order to get at some idea of the best method of treatment. Without such co-operation on the part of the grower we can do but little toward remedying such a disease as this, which does not occur everywhere, and consequently can only be experimented upon wherever it may happen to break out. The same is true with many other diseases, especially those affecting various hot-house plants. If we could plant chrysanthemums and be sure of getting rust, mildew and leaf spot, and similarly with other plants, if we could be sure of getting all their diseases, then our opportunities for experiment would be unlimited; but such, of course, is not the case. While some diseases are very general, many others appear only here and there, and the opportunities for experiment are limited to those places. We will gladly aid any one as much as possible in carrying on such experiments, and will give them our personal attention so far as we may be able.

"Drop" of Lettuce.

This disease has been for the last few years the most difficult one with which the lettuce growers about Boston have had to contend. Some growers always have a large number of plants attacked, while others have it so badly that they frequently lose half the crop. The annual loss to the lettuce growers about Boston from this disease alone amounts to several thousand dollars. The effect of the disease shows itself in a single night, and it is not very difficult to detect, inasmuch as the whole plant simply collapses. It not only makes its appearance on the young plant a few weeks old, but on the mature ones as well. Lifting the diseased plant out of the soil, it shows at once that the trouble is localized in the soft, rotten stem, which is not unusually covered with fungous growths sufficiently thick to be seen with the naked eye. Examination made with the microscope reveals the presence of numerous fungous filaments ramifying throughout the stem and root. The organism causing the disease is a species of damping fungus (Botrytis), which has previously been described in the ninth annual report of this station.

Practical lettuce growers resort to various methods in order to contend with this foe, but none of them have proved wholly effectual. Most of them recognize the fact that the source of contamination is largely in the soil, and that the disease is much more troublesome in old soil than in new. This is what might be expected, especially when the old decomposing roots are left in the soil, as they often are, thus offering the most favorable conditions for the spread of the disease. As a means of controlling it, some growers have resorted to changing the soil, with beneficial results; while others make a practice of covering the surface with a layer of pure sand or yellow subsoil, about one inch in depth. The burning of sulphur in the house before a new crop is set is also practised, and this might be expected to kill the spores with which it comes in contact; but it is very doubtful whether the sulphur affects the spores in the soil to any great extent. It appears, however, that sulphur penetrates the soil somewhat, and, on account of the injury which young plants are known to receive from sulphur, they should not be set for a few days after it is used.

The disease appears to be more common than formerly, and this is partially due to the practice of running high night temperatures. The collapse of the plant is most likely to occur during the night, and with a lower night temperature — for example, one not exceeding 38° to 40°F. — the trouble would no doubt occur less frequently. The opportunities for treating the soils with chemicals do not appear to us to be very promising, for the reason that solutions which would be likely to cause the death of the fungus would have to be used in very large quantities, as well as much stronger than in ordinary cases, and they would be likely to cause injury to the crop. My experiments in applying a great variety of chemicals to the soil have shown that, while a comparatively weak solution accomplishes all that can be desired in the laboratory, when applied to the soil the effect of even much stronger solutions more copiously applied is radically different. So long as the tendency is to force crops more and more, it must be expected that the gardener will have numerous abnormal conditions to contend with.

No doubt the most successful and I believe the cheapest

method in the long run would be to apply heat as a remedy for fungus and other pests in the soil. I have used a great many pots of earth heated with steam up to 130° to 200°F., with the most beneficial results, not only in the subsequent growth of the plant, but also in destroying the troublesome pests which infest the soil. The soil under glass could be easily fitted up with a system of irrigating tile, which could be used not only for purposes of irrigation, but also for forcing steam through them and partially sterilizing the soil. I have not as yet had an opportunity of treating this fungus with heat, but I should suppose that, if the soil was heated to 200° F., it would result in its death.

Physiological Disorders.

Wilt of Maple Leaves.

Last May a number of maple leaves in a dry and crispy condition were sent to this department from various parts of the State, under the supposition that they were affected by some form of fungus or insect life. Examination of the leaves, however, by Mr. Robert A. Cooley of the insectary, showed that no form of either of these organisms could be found. All of the leaves that were sent in were those of the sugar maple (Acer saccharinum), although the same condition was observed in a large number of different varieties of Japanese maple growing on the college grounds. Moreover, they showed the wilt only on one side of the tree, namely, the west, that being the direction of the prevailing wind the day upon which they were affected; and this peculiarity — so far as could be learned — was the same all over the State. This phenomenon is especially interesting, as it occurs on apparently healthy trees under certain exceedingly unusual conditions, — conditions, too, which, lasting only a few hours, are yet capable of giving rise to abnormalties of function. We attribute the wilting of sugar-maple leaves, which occurred quite generally throughout Massachusetts on May 18, to an excessive transpiration or evaporation of water from the leaves, at a time when the water supply of the roots was extremely limited. This was brought about by a remarkable combination of meteorological conditions favorable

to this result. It is well known to vegetable physiologists that agitation of the leaves of a plant greatly accelerates the process of transpiration, that is to say, the evaporation of water from the leaves. It is also well known that transpiration is accelerated by light, a low relative humidity and a high temperature. Such were just the conditions upon May 18.* During the months of April and May the rainfall was far below the normal, while the long-continued drouths of the two preceding years will be well remembered. Thus it is evident that the supply of water available to vegetation must have been much less than usual, and under the unusually strong, dry and warm wind of May 18, the leaves of a tree like the maple, with its large leaf surface, might be expected to become greatly exhausted and wilt badly. When this wilting was not carried to excess the leaves recovered; when, however, it went too far, it resulted in a dying and subsequent shrivelling of the foliage.

Another factor which must not be overlooked in accounting for this disorder is the maturity of the foliage. Young leaves always give off the greatest amount of water, and the maple leaves in May are giving off their maximum quantity.

With plenty of water in the soil these high winds would not have caused any wilting; or, if the same conditions had ensued during August or September, when the foliage was more mature, less wilting would have resulted. The west side of the trees, being the side exposed to the prevailing winds, was the most severely affected.

Top-burn of Lettuce.

A disease occurring on greenhouse lettuce, and characterized as "top-burn" came under our observation the past winter. The disease can readily be distinguished by the withering and subsequent turning back of the tip and margin of the outer leaves, the blackened area sometimes extending inwards an inch or more from the margin. This feature greatly disfigures the plant and consequently affects its

* Meteorological conditions were as follows: total precipitation, April, 1896, 1 32 inches; April, 1895, 5.60 inches; May 1–18, 1896, .16 inch. May 18, maximum velocity of wind 71 miles per hour; relative humidity, 47.31 (average for May, 62 5); number hours sunshine, 13 (in possible 14½); maximum temperature, 84°.

market value, but the real damage to the lettuce plant is never sufficient to destroy it. Microscopic examination of the blackened areas frequently shows bacteria in the cells, but more often the "damping fungus" (Botrytis) is present, and can be readily observed with the naked eye. In this instance, however, neither of these forms of organisms has anything to do with the cause of the disease. They are simply accompanying factors, which are always ready to seize upon any abnormal condition in the plant which is especially favorable to them. The disease is a physiological one, and has its origin in the unfavorable surroundings of the plant, especially those connected with transpiration and sunlight. Mr. B. T. Galloway of the United States Department of Vegetable Physiology and Pathology has made this disease a study, and I can do no better than to quote his views: —

Top-burn, one of the worst troubles of the lettuce grower, does comparatively little injury on this soil [Boston soil], providing the proper attention is given to ventilation and the management of the water and heat. Burn is the direct result of the collapse and death of the cells composing the edges of the leaves. It is most likely to occur just as the plant begins to head, and may be induced by a number of causes. The trouble is most likely to result on a bright day following several days of cloudy, wet weather. During cloudy weather in winter the air in a greenhouse is practically saturated, and in consequence there is a comparatively little transpiration on the part of the leaves. The cells, therefore, become excessively turgid, and are probably weakened by the presence of organic acids. When the sun suddenly appears, as it often does after a cloudy spell in winter, there is an immediate rapid rise in temperature, and a diminution of the amount of moisture in the air in the greenhouse. Under these conditions the plant rapidly gives off water, and, if the loss is greater than the roots can supply, the tissues first wilt, then collapse and die. The ability of the roots to supply the moisture is affected by the temperature of the soil, the movement of water in the latter and the presence or absence of salts in solution. In this soil the temperature rises rapidly as soon as the air in the greenhouse becomes warm, and the roots in consequence immediately begin the work of supplying the leaves with water. The movement of the water in the soil is also rapid, so that the plant is able to utilize it rapidly.

While I have never seen the disease in the lettuce houses about Boston, the growers seem to be acquainted with it; and it is no doubt the superior skill which they possess that enables them to be free from it. One grower informed me that he always saturated his house with moisture in bright, sunshiny days which were preceded by cloudy weather, and by this means was able to prevent it.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

In the early part of 1896 the gypsy moth report mentioned last year was published by the State. This work consists of a bound volume of 608 pages, with 3 colored and 63 uncolored plates, and with 5 maps and 37 cuts in the text. The first part, comprising 263 pages, was prepared by the field director, and the second part, 244 pages, by myself, while the Appendix of 100 pages contains the reports of visiting entomologists and other papers. This work represents all that we were able to learn, up to the time of publication, of the history and habits of the notorious gypsy moth, its ravages in foreign countries as well as in our own, the means used for fighting it in other lands and also its natural enemies. Our experiments with methods for the destruction of this insect are still in progress, and occupy a large amount of time in study and work.

Quite extended studies have been carried on during the year on the spruce gall-louse (*Chermes abietis* Linn.), mainly by my assistant, Mr. R. A. Cooley, who with great care and perseverance has worked out the life history of this insect, which causes peculiar cone-like galls to form on the twigs of different varieties of spruce, rendering them unsightly and often nearly destroying them. The results of these studies are published in the thirty-fourth annual report of the college, with two plates showing the work and different stages in the life of this insect. Mr. Cooley was fortunate enough in his experiments to discover a good practical remedy for this insect, which consists in spraying the trees with a strong solution of whale-oil soap at the time these insects are in the most exposed state, which occurs during the winter or in the early spring, and also to cut off and burn the new galls in June before the insects

leave them. About five hundred circular letters were sent to all parts of the country last spring, and from the replies to these it appears that this insect already has a wide distribution in this country, and it is quite probable that in time it may become distributed wherever spruces grow.

Considerable time has been devoted to the study of cranberry insects during the summer, three trips having been made to the bogs on Cape Cod at the most favorable time for the study of these insects. There are, however, so many different species attacking the vines, and their mode of attack is so different one from another, that to learn their habits and the most effectual and economical method of destroying them forms a problem of no easy solution. We are therefore not yet ready to publish a final bulletin on these insects.

The army-worm has been unusually abundant the past year in many parts of the State, and numberless calls have been made on this department for information concerning the insect; in fact, the correspondence about the army worm during the summer was far greater than that of all other insects combined. Fortunately, we had already published a bulletin on this insect, and Mr. Kirkland, my assistant on the gypsy moth work in Malden, published an article on the army-worm in the "Crop Report" for September, 1896. It is not possible to foretell whether this insect will occur in injurious numbers next summer; but such a case would be quite unusual, as it has very rarely if ever in the past been abundant in the same locality two years or more in succession.

The elm-leaf beetle has not been so abundant in this State during the past summer as it was the year before, and this is true, as I learn, in other States. What the real cause of this decrease in numbers may be, I do not know. It may be due to a rapid increase of its vegetable parasites favored by a wet season. This, however, is all conjecture, as I have no positive evidence in the case.

The San José scale has occupied much attention; and, at the request of the president of the Shady Hill nurseries, I sent an assistant to make a critical examination of their stock at Bedford, Mass., and he reported to me that he discovered a large amount of infested stock in that nursery, which the

president promised to have burned. An examination made late this fall reveals the fact that the scale has not been entirely cleared from it. How widely this scale may be distributed in this State I am not able to say.

On the 12th of May I received a letter from L. C. Holt, Esq., of Ashby, Mass., and also a box of caterpillars which he stated were in immense quantities on the blueberry bushes, entirely stripping them of their leaves, and that unless something were done at once there would be no blueberry crop, and this would be a great misfortune, as many poor people derived quite a revenue from the berries picked from these bushes. The caterpillars proved to be the currant span worm (*Diastictis ribearia* Fitch) ; but the great difficulty which now presented itself was to offer some remedy which would not be as expensive as the value of the crop. I could think of no better or cheaper mode of destroying these span worms than to spray the bushes with Paris green in water, in the proportion of one pound of the former to one hundred and fifty gallons of the latter, and advised this course, if the crop was of sufficient importance to warrant the expense. This is the first time I have ever heard of this insect attacking the blueberry.

On the 17th of November I received a letter enclosing some twigs with scale insects on them from Mr. James Draper, who wrote me that they were taken from a golden-oak tree in one of the gardens of the city of Worcester, Mass. The scales proved to be what is known by the name of *Planchonia quercicola*, a European scale insect which has been in this country for some time. The first account of it here, so far as I know, was given in the report of the Department of Agriculture for 1880, page 330, where it is stated that it was found upon the imported oaks in the Department of Agriculture grounds at Washington. The insect has been found in New Jersey and also in New York, as I am informed by Professor Howard. It is regarded as a very injurious scale, and every effort should be made to destroy it by cutting off and burning the infested twigs, and thoroughly spraying the trees with whale-oil soap dissolved in water.

REPORT OF THE CHEMIST.

DEPARTMENT OF FOODS AND FEEDING.

J. B. Lindsey.
Assistants, E. B. Holland, G. A. Billings,* B. K. Jones.

Part I.

Laboratory Work.

Outline of year's work, together with chemical investigations of a technical character.

Part II.

Feeding Experiments and Dairy Studies.

(*a*) Effect of narrow and wide rations upon the quantity and cost of milk and butter, and upon the composition of milk.
(*b*) Rice meal *v.* corn meal for pigs.
(*c*) Oat feed *v.* corn meal for pigs.
(*d*) Digestion experiments with sheep.

Part III.

Compilation of fodder analyses.
Compilation of fertilizer constituents of fodders.
Compilation of analyses of dairy products.
Compilation of digestion coefficients.

* Left Sept. 1, 1896.

PART I.

We have continued to analyze, free of cost, all feed stuffs, dairy products and waters sent to the station during the year. Results have been reported as promptly as possible, together with such comments as were considered necessary. There have been tested 63 samples of feed stuffs, 89 samples of whole milk, 11 samples of skim-milk, 9 samples of cream and 6 samples of butter; also 31 samples of milk and 20 samples of butter for the Dairy Bureau. These results are tabulated at the end of this report.

There have also been examined 134 samples of water, of which 10, or 7.5 per cent., were pronounced excellent; 50, or 37.5 per cent., fair; 39, or 29.1 per cent., suspicious; and 35, or 26.1 per cent., dangerous for drinking purposes.

In addition to the analyses above mentioned, which may be regarded as control work, we have made a very large number of analyses of feed stuffs, manures and milks, in connection with various animal experiments.

We have also spent considerable time in attempting to estimate some of the various substances composing the non-nitrogenous extract matter, and have compared different methods for the determination of starch in different feed stuffs, with a view of selecting one that will most correctly ascertain the true starch, when in combination with other substances of a similar nature. The results of some of the work are very briefly presented under the following heads: * —

1. *Remarks relative to the carbohydrates of agricultural plants and seeds.*
2. *Distribution of galactan.*
3. *The phloroglucin method for the estimation of pentosans.*

* The work reported under these headings is of a technical character.

SOME REMARKS RELATIVE TO THE CARBOHYDRATES OF AGRICULTURAL PLANTS AND SEEDS.

J. B. LINDSEY.

Agricultural chemists have divided the dry matter of plants into five groups of substances, namely, crude ash, crude fibre, crude fat or ether extract, and non-nitrogenous extract matter. These terms, as is well known, do not stand for single ingredients, but rather for groups of substances having similar characteristics. The terms crude fibre and extract matter are spoken of collectively as carbohydrates. Our knowledge of the individual substances composing the fibre and extract matter has until recently been rather vague. The investigations of Tollens, Schulze and their pupils have, however, thrown considerable light, and revealed the presence and characteristics of many of the substances entering into their composition. The crude fibre of agricultural plants, as prepared by the method employed by Henneberg and Stohmann, is now known to consist principally of dextroso-cellulose (a hexa-cellulose), combined with more or less lignin or lignin acids. The fibre has also been found to contain considerable pentosan, so intimately associated with the hexa-cellulose as to be considered a penta-cellulose. Whether the penta-cellulose is actually united with the lignin as a ligno-cellulose is uncertain. The true celluloses are characterized principally by their nearly complete insolubility in dilute mineral acids and in F. Schulzes' reagent, and by their solubility in copper ammonium oxide. When cellulose is dissolved in quite concentrated sulphuric acid, and the resulting product hydrolized with dilute acid, Schulze has as a rule obtained dextrose; hence the name dextroso-cellulose. Schulze found that the cellulose obtained from wheat bran, peas and lupine seeds yielded only dextrose; that obtained from rye straw, lupine pods, spruce wood and

red clover, gave dextrose and xylose; while that prepared from the coffee bean, cocoanut and sesame cake, yielded dextrose and mannose. There exist, therefore, dextroso-, mannoso- and pentoso- celluloses. That the so-called crude fibre is not pure cellulose, but in addition to both hexa- and penta- cellulose contains more or less lignin, is probable from the fact that it is colored a bright red by phloroglucin and hydrochloric acid, and because it contains a higher percentage of carbon than pure cellulose. When the dried and finely ground plant or seed is treated according to the Weender method, a considerable portion of the lignin is split off, and reckoned as extract matter.

The term non-nitrogenous extract matter is meant to include all substances, not included within the other four groups, that are removed by means of dilute acid and alkali. In case of the grains, the extract matter is known to consist largely of starch; but when derived from coarse fodders, leguminous seeds and many by-products, its composition has been, until the investigations of Tollens and Schulze, but little understood.

To these carbohydrates that can be removed from the plant by the action of dilute mineral acid and alkali, and that are as a rule soluble in F. Schulze's reagent, E. Schulze has applied the name *hemi-cellulose*. Under this head he would bring the mother substances, dextran, levulan, mannan, galactan, araban and xylan, which yield, on inversion, the sugars dextrose, levulose, mannose, galactose, arabinose and xylose. It is the mother substances of these sugars and probably others of a similar nature not yet identified, together with ready-formed sugars, starch, and a portion of the lignin, as above alluded to, which constitute the extract matter. These hemi-celluloses are intermixed with the true celluloses and ligno-celluloses in the cell walls of plants and seeds. In some cases they have been recognized as reserve material, and are used as food in the sprouting of the seed. The levulan and mannan do not appear to be generally distributed. The araban and xylan (pentosans), on the other hand, constitute fully one-third of the extract matter of all hays and straws; they are quite prominent in the hull and bran of different grains and seeds, and are even found in the endosperm and cotyledons of many seeds.

THE DISTRIBUTION OF GALACTAN.

J. B LINDSEY and E. B. HOLLAND.

Galactan, one of the hemi-celluloses, was first extracted from lucerne seeds by Müntz,* and was converted into galactose by boiling with dilute acid. E. Schulze † and his co-workers found galactan quite prominent in the seeds of the blue lupine. The finely ground seeds were extracted with ether, alcohol, one per cent. soda solution at a low temperature to remove albuminoids, washed with water, and the residue boiled with dilute sulphuric acid. The solution was afterwards neutralized with barium carbonate, filtered, and evaporated to a syrup. This syrup was extracted with hot alcohol, and the alcoholic solution on slow evaporation yielded sugar crystals which proved to be galactose. The mother substance, yielding galactose, was also found to contain a pentose (probably arabinose). Schulze, therefore, called the substance para-galactoaraban. An examination of the pea, soy and field bean, showed the presence of the same substance. The coffee bean, date seed, palm and cocoanut cake proved the presence of galactan and mannan in liberal quantities, indicating the presence of a substance which might be termed galactomannan. Whether these substances are chemically united into complex molecules, or whether they are simple mixtures, it is hardly possible to state.

As a result of this work, Schulze assumed that the hemi-cellulose galactan might be very generally distributed in agricultural plants; and, if such should be the case, it must be of importance as a source of nutrition.

* Bull. Soc. Chim. (2) 37, p. 409.

† Zeitsch für physiol. chem. Bd 14. Heft 3; Zeitsch für physiol. chem. Bd 16, Hefts 4 and 5.

Recognizing the comparatively few fodder plants and seeds that had been tested for galactan, we thought it would prove interesting to make a quantitative estimation of the amount of the substance present in all the more important feed stuffs. While the method employed by Schulze, namely, the inverting of the galactan with dilute mineral acid and allowing the resulting sugar to crystallize out, is of course a sure proof of the presence of galactose, if properly identified, it does not admit of a *quantitative estimation* of the sugar. We therefore had recourse to the indirect method of estimating the mucic acid, as a measure of the quantity of galactose present. Scheele * was the first to recognize that by the oxidation of milk sugar, mucic acid resulted. Pasteur † found that it was the galactose of the milk sugar that yielded mucic acid. Tollens and Kent,‡ after numerous experiments, proposed the following method for obtaining the largest amount of mucic acid both from milk sugar and from galactose. They evaporated 100 grammes of milk sugar with 1,200 c.c. of nitric acid of 1.15 specific gravity in a water bath to one-third of its volume, allowed the solution to stand twenty-four hours for the mucic acid to crystallize out, then filtered onto a tared filter and dried and weighed it. This method yielded 37 to 40 per cent. of mucic acid. When pure galactose was used, a double quantity — 74–77 per cent. — was obtained.§ Rischbieth, Creydt, Hadecke and Tollens still further perfected the method, and used it in ascertaining the galactan in a variety of substances. This perfected method we have used with but slight modifications in the estimation of galactan in the substances which follow.

Method. — Three grammes of the substance were brought into a beaker about 5.5 c.m. in diameter and 7 c.m. deep, together with 60 c.c. of nitric acid of 1.15 specific gravity, and the solution evaporated to exactly one-third of its volume in a water bath at a temperature of 94 to 96 degrees C. After standing twenty-four hours, 10 c.c. of water are added to the precipitate, and it is allowed to stand another twenty-four

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* Opuscula chemica et physica, Leipsig, 1789, p. 111.

† Comp. rend. 42, p. 347.

‡ Ann. Chem. 227, p. 221.

§ Landw. Versuchs-Stationen 39, p. 401.

hours. The mucic acid has in the mean time crystallized out, but is mixed with considerable material only partially oxidized by the nitric acid. The solution is therefore filtered through filter paper, washed with 30 c.c. of water, to remove as much of the nitric acid as possible, and the filter and contents brought back into the beaker. Thirty c.c. of ammonium carbonate solution* are now added, and the beaker brought into a water bath and heated gently for fifteen minutes. The ammonium carbonate takes up the mucic acid, forming the soluble muciate of ammonia. The solution is now filtered into a platinum or porcelain dish, and the residue thoroughly washed with water to remove all of the muciate of ammonia. The filtrate is then evaporated to dryness over a water bath, and 5 c.c. of nitric acid of 1.15 specific gravity are added, thoroughly stirred and allowed to stand for thirty minutes. The nitric acid decomposes the ammonium muciate, precipitating the mucic acid, which is now filtered onto a tared filter, or into a Gooch crucible, washed with 10 to 15 c.c. of water, with 60 c.c. of alcohol and quite a number of times with ether, dried at 100° C. for a short time, and weighed. The mucic acid multiplied by 1.33 gives galactose, and this multiplied by .9 gives galactan.

The method gives fairly good results, but, like other methods that are employed in estimating substances formed by physiological processes, absolute accuracy is hardly to be expected. For example, when extracting the mucic acid from the impurities with ammonium carbonate, more or less of the partially decomposed organic matter is dissolved out, which is again precipitated by the addition of the nitric acid. After the mucic acid is filtered and washed with alcohol and ether, a considerable portion of this material is dissolved out; some, however, still remains, and gives the otherwise white mucic acid a grayish color. It is possible that such a condition might be obviated by previously treating the *substance to be examined* with alcohol, ether and one per cent. soda solution in the cold, in order to remove fat, coloring matter and protein substances. Whether this could be done without loss of any of the substance is a question for further study.

* One part ammonium carbonate, 19 parts water and 1 part strong ammonia.

Results.

Coarse Fodder.

	Galactose.	Galactan.
	Per Cent.	Per Cent.
English hay,	1.01	.91
High-grown salt hay,	.93	.84
Black grass,	.71	.64
Corn stover,	.76	.68
Oat straw,	.81	.73
Rye straw,	.63	.57
Fodder millet,	.95	.86
Canada beauty pea fodder,	3.09	2.78
Medium red clover fodder,	3.73	3.36
Alsike clover fodder,	4.25	3.83
Mammoth clover fodder,	3.77	3.39

Concentrated Feeds.

	Galactose.	Galactan.
Corn meal,	.05	.05
Wheat meal,	.23	.21
Oat meal,	.81	.73
Barley meal,	.55	.50
Wheat bran,	.43	.39
Millet meal,	.67	.60
Linseed meal,	1.31	1.15
Cotton-seed meal,	.63	.57
Rice meal,	1.04	.96
Rape seed,	1.07	.96
Brewers' grain,	.56	.50
Malt sprouts,	.43	.39
Dwarf horticultural bean,	.68	.61
Green soy bean,	.67	.60
Black soy bean,	.92	.83
Bush lima bean,	.79	.71
Pole lima bean,	.66	.59
Black wax bean (dwarf),	.52	.47
White pot bean,	.53	.48
Horse bean,	1.83	1.65
Canada beauty pea,	.63	.57
Prussian blue pea,	.75	.68
English gray pea,	.84	.76
Little gem pea,	1.16	1.04
Wonder pea,	1.62	1.46
Pea meal,	2.69	2.42
Vetch seed,	1.17	1.05
Serradella seed,	.66	.59
Medium red clover seed,	2.77	2.49
Mammoth clover seed,	3.63	3.27
Crimson clover seed,	3.49	3.14
Alsike clover seed,	8.96	8.06
Sweet clover seed,	6.00	5.40
White clover seed,	10.08	9.07
Alfalfa seed,	5.23	4.71
White lupine seed,	13.84	12.46
Blue lupine seed,	16.29	14.66

Many of the substances tested show less than one per cent. of galactan, and we are not certain in many cases, because of the small amount of precipitate obtained, whether the material weighed really was mucic acid or partially decomposed organic matter. All substances, therefore, containing less than one per cent. of galactan, may be for the present characterized as doubtful. To settle the presence or absence of very small amounts of galactan, we shall either be obliged to still further perfect the method, or work with larger quantities. Tollens states that mucic acid melts at 213 degrees C. We have tested the melting point of the precipitate in cases when there was sufficient present, and found a melting point of about 215 degrees C.

The results as given above show the presence of very small amounts of galactan in the non-leguminous coarse fodders and seeds. In the leguminous plants from three to four per cent. are present, while in case of the leguminous seeds, several varieties of beans and peas appear to contain very limited quantities, but the larger number of such seeds tested show from 1½ to as high as 14 per cent. With the exception of the lupines, the clover seeds contain the largest amounts, the seeds of white variety containing 9 per cent.

The above results are merely a report of progress. They show, however, that the galactans are not as widely distributed nor present in such large quantities as are the pentosans, and therefore do not play such an important part as do the latter in the process of nutrition. We propose to continue the investigation of the distribution of these substances, and also to determine their digestibility.

THE PHLOROGLUCIN METHOD FOR THE ESTIMATION OF PENTOSANS.

J. B. LINDSEY and E. B. HOLLAND.

Councler * has suggested that, instead of phenylhydrazin, phloroglucin be employed for the precipitation and estimation of furfurol obtained by the distillation of various substances, with dilute hydrochloric acid. Kruger and Tollens † have further studied and perfected the method, and recommended it as reliable for the estimation of pentosans in various coarse fodders, grains and vegetables.

The phloroglucin, like the phenylhydrazin method, is based on the fact that the pentosans (araban, xylan, etc.) differ from other carbohydrates in that they yield furfurol instead of levulinic acid upon digestion with moderately dilute hydrochloric or sulphuric acids. The first step necessary in both processes for a quantitative estimation is the conversion of the pentosans into furfurol and its separation from the resulting by-products.

Phloroglucin Method described.

Three grammes of the material are brought into a ten-ounce flask, together with 100 c.c. of 12 per cent. hydrochloric acid (specific gravity, 1.06), and several pieces of recently heated pumice stone. The flask, placed upon wire gauze, is connected with a Liebig condenser, and heat applied, rather gently at first, and so regulated as to distil over 30 c.c. in ten to fifteen minutes from the time that boiling begins. The 30 c.c. driven over are replaced by a like quantity of the dilute acid, by means of a separatory funnel; and the process so continued as long as the distillate gives a pronounced reaction with aniline acetate on filter paper (a

* Chemikerztg, 1894, No. 51. † Zeitsch. für Ang. Chem., 1896, Heft II.

few drops of aniline in a little 50 per cent. acetic acid). To the completed distillate is gradually added a quantity of phloroglucin * dissolved in 12 per cent. hydrochloric acid, and the resulting mixture thoroughly stirred. The solution first turns yellow, then green; and very soon an amorphous greenish precipitate appears, which grows rapidly darker, till it finally becomes almost black. The solution is made up to 500 c.c. with 12 per cent. hydrochloric acid, and allowed to stand over night. In case there is very little furfurol in the substance tested, and the resulting distillate consequently small, it is best to add sufficient 12 per cent. hydrochloric acid to the distillate before adding the phloroglucin solution, so that, upon the addition of the latter solution, the resulting mixture will contain approximately 500 c.c.

The amorphous black precipitate is filtered into a tared Gooch crucible through an asbestos felt, washed with 100 c.c. of water, dried to constant weight by heating three to four hours at 100 degrees C., cooled and weighed, the increase in weight being reckoned as phloroglucid. To calculate the furfurol from the phloroglucid,† use the following table: —

TOTAL WEIGHT OF PHLOROGLUCID OBTAINED.	Divided by, equals Furfurol.	TOTAL WEIGHT OF PHLOROGLUCID OBTAINED.	Divided by, equals Furfurol.
.20 gramme, . .	1.820	.34 gramme, . .	1.911
.22 " . .	1.839	.36 " . .	1.916
.24 " . .	1.856	.38 " . .	1.919
.26 " . .	1.871	.40 " . .	1.920
.28 " . .	1.884	.45 " . .	1.927
.30 " . .	1.895	.50+ " . .	1.930
.32 " . .	1.904		

Furfurol ÷ by grammes substance taken × 1.84 = pentosans.
Furfurol ÷ by grammes substance taken × 1.65 = xylan.
Furfurol ÷ by grammes substance taken × 2.03 = araban.

* Dissolve twice as much dry phloroglucin as furfurol expected in about 50 c.c. of 12 per cent. hydrochloric acid. Bring the hydrochloric acid into a water bath, and stir thoroughly till the phloroglucin goes into solution.

† The phloroglucid is a complex substance, of uncertain formula. It contains 63 to 64 per cent. of carbon and from 3.6 to 4.2 per cent. of hydrogen. The factors for calculating the amount of furfurol from the phloroglucid were obtained after experimenting with known amounts of pure furfurol and phloroglucin.

The amount of pentosans was estimated by both the phenylhydrazin and the phloroglucin methods in the following substances: —

	Phenylhydrazin Method (Per Cent.).	Phloroglucin Method (Per Cent.).
English hay,	21.28	22.50
High-grown salt hay,	25.64	25.74
Branch grass,	24.65	26.43
Low meadow fox grass,	27.98	27.91
Buffalo gluten feed,	16.45	16.00
Lupine seeds,	9.42	9.64

With two exceptions the two methods show very closely agreeing results. We propose to still further compare these methods in the near future. The phloroglucin method, on account of its greater simplicity, is much to be preferred.

Part II.

(a) THE EFFECT OF NARROW AND WIDE RATIONS ON THE QUANTITY AND COST OF MILK AND BUTTER, AND ON THE COMPOSITION OF MILK.

J. B. LINDSEY, E. B. HOLLAND and GEO. A. BILLINGS.

Results of Two Experiments.

I. Definition: By narrow ration is meant one containing 4 to 5 times as much carbohydrates as protein (1 : 5); by wide ration one containing 8 to 10 times as much carbohydrates as protein (1 : 10).

II. The same amount of digestible matter in narrow rations produced from 11.8 to 12.9 per cent. more milk than did a like amount of digestible matter in wide rations; narrow rations also reduced the cost of production from 5 to 12 per cent.

III. The average cost of a quart of milk produced with the narrow rations was 1.81 cents, and with the wide rations 1.97 cents.

IV. The narrow rations produced over the wide rations practically the same relative increase in the amount of butter and the same decrease in the cost of production as in the case of the milk.

V. The narrow rations produced butter at a cost of 15.57 cents per pound, and the wide rations at a cost of 16.52 cents per pound.

VI. In Experiment I., with the narrow rations, the best cow produced 12.2 pounds of butter in a week, at a cost of 14 cents per pound; and the poorest cow produced 8.26 pounds, at a cost of 19.37 cents per pound. In the same experiment, with the wide ration, the best cow produced 9.52 pounds, at a cost of 16.67 cents per pound; and the poorest cow produced 7.28 pounds, at a cost of 18.88 cents per pound.

In Experiment II., on the narrow ration, the best cow produced 12.81 pounds of butter per week, at a cost for feed consumed of 11.66 cents; and the poorest cow 7.98 pounds, at a cost of 15.90 cents per pound. With the wide ration, the best cow produced 10.92 pounds per week, costing 12.71 cents; and the poorest cow 6.86 pounds, costing 16.21 cents per pound.

VII. In these two experiments narrow rations produced manure having 20 per cent. more fertilizing value than that produced by wide rations. In general, it can be said that narrow rations produce manure containing 10 to 15 per cent. more fertility than wide rations.

VIII. Neither the narrow nor wide ration produced any decided change in the composition of the milk.

IX. For total consumption of dry and digestible matter; total yields of milk, milk solids and fat; pounds of milk, milk solids and fat produced by 100 pounds of dry and digestible matter; and for digestible matter required to produce 100 pounds of milk, 1 pound of milk solids and 1 pound of butter,— see tables XII., XIII. and XIV., in rear of this report.

A. Methods employed in carrying out the Experiments.

Plan.

The experiments were two in number, and were conducted during the autumn and winter of 1895–96, with six cows. The animals were divided as evenly as possible into two lots, and the experiments were so arranged that in the first half of each experiment three of the cows were fed the narrow rations while the other three were receiving the wide rations; in the second half of the experiment the order was reversed. In this way the natural milk shrinkage as well as the natural change in the quality of the milk was equalized. In the first experiment the two halves each lasted twenty-six days, and at least seven days were allowed after the animals were placed upon the full ration before the actual test began. In Experiment II. the halves each lasted twenty-one days.

History of Cows.

NAME.	Breed.	Age.	Last Calf dropped.	Milk Yield at Beginning of Experiments. I.	II.
		Years.		Pounds.	Pounds.
I. Ada, . . .	Grade Ayrshire, .	7	Oct. 1,	26	22
II. Una,* . . .	Native, . . .	10	Sept. 1,	22	-
II. Guernsey,† . .	Grade Guernsey, .	7	Dec. 1,	-	30
III. Bessie, . . .	Grade Ayrshire, .	7	Sept. 10,	27	26
IV. Beauty, . . .	Grade Jersey, . .	5	Sept. 15,	27	20
V. Red, . . .	Grade Durham, . .	7	Oct. 8,	33	27
VI. Spot, . . .	Grade Durham, . .	7	Oct. 8,	34	27

* Used in first experiment. † Used in second experiment.

The animals had been purchased in the neighborhood, at an average cost of $50 each, when fresh. They were better animals than the average, and most of them had been dry for several months before calving, so that they would naturally be able to do their best work during the two experiments now being described. None of the animals had been served at the beginning of the experiment, but they were allowed to take bull later. Most of them were served between the two halves of the first experiment.

Feeds and Feeding.

In the first experiment all of the cows were fed hay and sugar beets as coarse feeds. In the wide ration half, each cow had one pound more of hay daily than in the narrow ration half, in order to make up a like amount of total digestible daily nutrients. Chicago gluten meal and wheat bran were fed in the narrow ration, and corn meal and wheat bran in the wide ration. The hay was quite coarse, and consisted of Timothy, with an admixture of clover. Cow II. left a small quantity of the coarser portion in one half, which was deducted from the amount consumed in calculating the digestible daily nutrients eaten.

In the second experiment the coarse feeds consisted of hay, and millet and soy bean ensilage; the concentrated feeds in case of the narrow ration were bran, Chicago gluten

meal and old-process linseed meal; and in case of the wide ration, wheat bran and corn meal. In this experiment the feeds were entirely consumed.

The feeds were very carefully weighed out, and given twice daily. Water was kept before the animals constantly, by means of the Buckley self-watering device. A cover swung upon hinges kept the feed from getting into the water. The animals very soon learned to lift the cover whenever they desired to drink.

Sampling the Feeds.

A small sample of the different grain feeds was taken daily, and preserved in glass-stoppered bottles; a sample of the hay was taken weekly, and likewise preserved; and at the end of each of the two halves of each experiment dry-matter determinations were made and samples preserved for analysis. In case of the sugar beets and ensilage, samples were taken weekly and tested for dry matter at once, and at the close of the experiment these several samples were mixed and preserved for analysis.

General Care.

The cows were milked twice daily, about five o'clock in the morning and five in the afternoon, always by the same attendant, who was a graduate of the college, and thoroughly trustworthy. The animals were carded daily, and allowed the run of a yard in pleasant weather. They were given plenty of stall room, and made as comfortable as possible. The wing of the stable in which they were confined contained no storage room, and each animal was allowed fully 1,200 cubic feet of air. The wing was heated with hot water, and kept at a temperature of 50 to 55 degrees F. during the winter months. Ventilation was secured by means of a shaft 8 by 15 inches, placed at the south end of the wing, running to within 1 foot of the floor, and extending 12 feet above the roof, terminating in a so-called Archimedean ventilator. In the shaft was placed a hot-water coil, to increase the draught. Air was admitted by means of windows opening into the barn, thus avoiding direct draughts. The windows were sufficient in number to keep the barn fully lighted.

Weighing the Animals.

The animals were weighed before feeding in the afternoon at the beginning and end of the experiment, and once a week during its continuance. It is recognized that this was not sufficient, and in experiments now being made the animals are weighed for three successive days at the beginning and end of the experiment and the same number of times weekly during its continuance.

Care of the Milk.

The milk was weighed at once after being drawn, on a Chatillon balance sensitive to two ounces. Composite samples were taken for five days of each week, the milk being preserved with the aid of bichromate of potash. In order to secure an average sample, it was poured from one pail to another three times, and then 10 c.c. removed with the aid of a pipette, an exact amount being taken at every milking. The glass jars containing the composite samples were kept tightly covered, and were gently rotated each day, to prevent any undue clotting of the cream.

Testing the Milk.

The tests were in all cases made in duplicate. The total solids were made either by the sand method or by use of the perforated disk filled with asbestos. The fat was determined by the gravimetric method, and in case of Experiment II. total nitrogen was estimated by the Kjeldahl method.

Experiment I.

DATES OF EXPERIMENT.	Narrow Ration.	Wide Ration.
October 24 through November 18, ...	Cows I., IV., VI.	Cows II., III., V.
November 28 through December 23, . . .	Cows II., III., V.	Cows I., IV., VI.

Experiment II.

January 27 through February 16, ...	Cows I., II., VI.	Cows III., IV., V.
February 29 through March 29, ...	Cows III., IV., V.	Cows I., II., VI.

B. Rations consumed, and their Effect on the Quantity and Cost of Milk and Butter.

Average Daily Rations fed to Six Cows (Pounds).

Experiment I.

CHARACTER OF RATION.	Wheat Bran.	Chicago Gluten.	Linseed Meal.	Corn Meal.	Hay.	Sugar Beets	Millet and Bean Ensilage.
Narrow ration, ...	3	5.83	-	-	15.17	12	-
Wide ration, ...	3	-	-	5.83	16.17	12	-

Experiment II.

CHARACTER OF RATION.	Wheat Bran.	Chicago Gluten.	Linseed Meal.	Corn Meal.	Hay.	Sugar Beets	Millet and Bean Ensilage.
Narrow ration, ...	2.83	3 00	1.92	-	10.33	-	28.33
Wide ration, ...	1.92	-	-	5.83	10.33	-	28.33

Average Weight of Animals and Total Digestible Nutrients in Daily Rations (Pounds).

Experiment I.

CHARACTER OF RATION.	Weight of Animal.	Protein.	Fat.	Carbohydrates.	Total.	Nutritive Ratio.
Narrow ration, ...	941	3.07	.59	10.23	14.06	1:3.86
Wide ration, ...	938	1.46	.52	12.45	14.43	1:9.43

Experiment II.

CHARACTER OF RATION.	Weight of Animal.	Protein.	Fat.	Carbohydrates.	Total.	Nutritive Ratio.
Narrow ration, ...	899	2.85	.65	9.96	13.46	1:4.04
Wide ration, ...	890	1.45	.54	11.44	13.42	1:8.85

The difference between the two rations in Experiment I. consists in the fact that gluten meal high in protein was substituted for corn meal low in protein. In Experiment II.

gluten and linseed meals were substituted for corn meal. It might have been better had the coarse feeds been increased somewhat, in order to have raised the total digestible nutrients to 15 pounds daily. The animals, however, maintained very even average weights during both experiments. In both halves of each experiment the total digestible nutrients were practically the same.

TABLE I. — *Yield and Cost of Milk.*

Experiment I. 26 Days (6 Cows).

CHARACTER OF RATION.	Total Yield (Pounds).	Average Daily Yield. Quarts.	Average Daily Yield. Pounds.	Total Cost of Feed consumed.	Cost of Feed to produce a Quart of Milk (Cents).	Cost of Feed to produce 100 Pounds of Milk (Cents).
Narrow,	4241.5	12.65	27.2	$36.84	1.89	87.0
Wide,	3695.5	11.03	23.7	35.34	2.11	95.7
Increase narrow over wide ration,	546.0	1.62	3.5	1.50	—.22	—8.7
Percentage increase,	12.9	-	-	-	—11.70	-

Experiment II. 21 Days (6 Cows).

CHARACTER OF RATION.	Total Yield (Pounds).	Average Daily Yield. Quarts.	Average Daily Yield. Pounds.	Total Cost of Feed consumed.	Cost of Feed to produce a Quart of Milk (Cents).	Cost of Feed to produce 100 Pounds of Milk (Cents).
Narrow,	3261.0	12.01	25.82	$26.27	1.74	80.6
Wide,	2877.0	10.58	22.73	24.43	1.83	84.9
Increase narrow over wide ration,	384.0	1.43	3.03	1.84	—.09	-
Percentage increase,	11.8	-	-	-	—5.20	-

The above table shows that the narrow rations produced from 11.8 to 12.9 per cent. more milk than did the wide rations, and that they reduced the cost of production from 5 to 12 per cent. At the end of Experiment II., six months after calving, the cows were averaging between 11 and 12 quarts of milk daily.* It was not the primary object of these two experiments to select the most economical feeds for milk production, but rather to note the effect of narrow *v.* wide rations on the *quality* of the milk. The figures, however, cannot fail to prove interesting to the milk producer.

* Cow No. 2, at the close of Experiment II., had been calved but three months.

TABLE II. — *Yield and Cost of Butter.*

Experiment I. 26 Days (6 Cows).

CHARACTER OF RATION.	Total Yield of Butter Fat.	Equivalent to Butter.	Average Daily Yield.	Average Weekly Yield.	Average Cost of Feed per Pound of Butter produced.
	Pounds	Pounds.	Pounds.	Pounds.	Cents.
Narrow,	190.90	222.71	8.55	59.85	16.74
Wide,	164.87*	192.01	7.11	49.77	18.41
Increase narrow over wide ration,	26.03	30.70	1.44	10.08	—1.67
Percentage increase,	13.70	13.70	-	-	—10.00

Experiment II. 21 Days (6 Cows).

CHARACTER OF RATION.	Total Yield of Butter Fat.	Equivalent to Butter.	Average Daily Yield.	Average Weekly Yield.	Average Cost of Feed per Pound of Butter produced.
Narrow,	157.69	183.98	8.75	61.25	14.40
Wide,	144.56	168.64	8.01	56.07	14.64
Increase narrow over wide ration,	13.13	15.34	.74	5.18	—.24
Percentage increase,	8.30	8.30	-	-	—1.67

The figures tell the same story as they did in the yield of milk. On the narrow rations the cows produced 13.7 per cent. more butter in Experiment I. and 8.3 per cent. more in Experiment II. than they did on the wide rations. In Experiment I. the cost of feed per pound of butter produced was 16.74 cents for the narrow ration and 18.41 cents for the wide ration, showing that the narrow ration produced butter for 10 per cent. less per pound than did the wide ration. In Experiment II. the cost of feed per pound of butter produced was 14.57 cents for the narrow and 14.64 cents for the wide ration, showing a difference of but 1.67 per cent. in favor of the narrow ration.

It is of course impossible to state with accuracy the exact cost of feed required to produce a pound of butter, as so

* Cow V. (Red) during a portion of this period produced milk with but 2.85 per cent. of fat, and then suddenly increased to 4 per cent. The above figures include this cow's production on the basis of 4.05 per cent. fat for the entire period; otherwise the percentage increase of the butter in the narrow ration would be more than the percentage increase in the milk produced, which might lead to the supposition that the narrow ration had actually increased the percentage of fat in the milk, when really this sudden increase of fat was entirely independent of the influence of the feed.

much depends upon the cost of feeds used, character of the cows, and the stage of lactation. The figures simply show what six of the better class of ordinary cows that had been well fed were able to do, during the first six months after calving.

Table III. — *Yield and Cost of Butter from Poorest and Best Cows.*

Character of Cow and Ration.	Experiment I.			Experiment II.		
	Daily Yield.	Weekly Yield.	Cost of Feed per Pound.	Daily Yield.	Weekly Yield.	Cost of Feed per Pound.
	Pounds.	Pounds.	Cents.	Pounds.	Pounds.	Cents.
Best cow, narrow,	1.74	12.20	14.00	1.83	12.81	11.66
Poorest cow, narrow,	1.18	8.26	19.37	1.14	7.98	15.90
Best cow, wide,	1.36	9.52	16.67	1.56	10.92	12.71
Poorest cow, wide,	1.04	7.28	18.88	.98	6.86	16.21

In Experiment I. the best cow on the narrow ration produced 12.2 pounds of butter per week, at a cost for feed consumed of 14 cents per pound; while the poorest cow produced 8.26 pounds, at a cost of 19.37 cents per pound. In the same experiment on the wide ration one cow produced 9.52 pounds per week, costing 16.67 cents per pound; and another 7.28 pounds per week, costing 18.88 cents.

In Experiment II. the best yield with the narrow ration was 12.81 pounds of butter per week, costing for feed eaten 11.66 cents per pound; and the poorest yield was 7.98 pounds, costing 15.90 cents. In the same experiment on the wide ration the best yield was 10.92 pounds weekly, costing 12.71 cents per pound; and the least yield 6.86 pounds weekly, costing 16.21 cents per pound. One is enabled from the above figures to note both the influence of the cow and the cost of the daily ration upon the cost of the butter produced. The cow yielding 12.81 pounds weekly, at a cost of 11.66 cents per pound for food consumed, was a grade Guernsey, fresh at the time. Her general form and appearance would not indicate that she was more than a very ordinary cow. She produced about 14 quarts of milk daily when at her best, containing 5.3 per cent. of butter fat. Such facts as the above ought certainly to stimulate farmers to ascertain the amount and quality of the milk produced by

their cows during a period of lactation. Only by such a course can the unprofitable cows be weeded out, and the herd brought to a higher standard. The scales and the Babcock tester are necessary; mere guess will not accomplish it.

TABLE IV. — *Approximate Estimate of the Amount and Value of Fertilizer Constituents in Excretions of the 6 Cows.*

CHARACTER OF RATIONS.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).	Relative Values of Same.
Average of Experiments I. and II., narrow, .	153	35	79	$28 65
Average of Experiments I. and II., wide, . .	108	40	95	22 95
Percentage increased value of narrow over wide ration, .				$19 20

For the sake of comparison, by figuring the value of the nitrogen, phosphoric acid and potash contained in the feeds consumed (less 20 per cent. for the amount retained in the system or otherwise lost) by the market cost of these several ingredients per pound, it will be seen that the manure from the narrow ration has 20 per cent. more value than that from the wide ration. The cause of the increased value lies naturally in the increased amount of nitrogen present. In case of the rations fed in these experiments, the fact that the wide ration has more potash than the narrow is because gluten meal, which served to increase the protein, contains but minimum amounts of this ingredient. If cotton or linseed meal had been used in place of the gluten meal, the reverse would have been true. While the so-called narrow rations as used in these experiments were extreme ones, it might be said that narrow rations which contain from 2 to 2½ pounds of digestible protein in a day's feed, aside from their causing a 10 per cent. increase in the milk yield, furnish in addition a manure from 10 to possibly 15 per cent. more valuable than do wide rations.

While narrow rations will unquestionably produce more milk and butter than wide rations, the relative cost of the milk and butter produced by the two rations will depend

upon the price of the concentrated feed stuffs. The markets, however, at the present time contain such a great variety of these products that the feeder can select those rich in protein at prices that will enable him to feed the narrow or so-called well-balanced rations to advantage.

In the closing remarks on this portion of the experiment, it is well to inquire what are to be considered as economical narrow rations. The German ration established so long ago by the late Emil von Wolff contained, for cows of 1,000 pounds weight, 2.5 pounds of digestible protein, .5 pounds of digestible fat and 13 pounds of digestible carbohydrates, with a proportion of protein to fat and carbohydrates of 1 to 5.4.

The writer is convinced that 2.5 pounds of digestible protein daily is amply sufficient, and seriously questions whether it is not too much. More than this amount, or even 2.5 pounds daily in the form of concentrated feed stuffs, if fed from eight to nine months each year, will soon tend to impair the milk-producing capacity of the cow. Some cows might be able to withstand such feeding longer than others. It might be advisable, for economic reasons, to feed as high as 3 pounds of digestible protein daily to average cows for two or three years, and then turn them into beef; but cows possessing more than ordinary merit should be differently handled. It should ever be kept in mind that it is far better to breed and select cows that possess extra milk and butter qualities than to attempt to attain those ends by extra amounts of concentrated feeds.

The amount of protein, as well as the amount of total digestible organic nutrients, that can be fed in the daily ration in order to produce milk and butter at low prices, and at the same time not impair the milk-producing organs by overwork, is still an uncertain quantity; and in order to secure more accurate information, taking into consideration American conditions, extended and carefully conducted investigations are necessary. Such experiments should be carried out only by those who can control all the conditions, who thoroughly understand the nature, handling and care of animals, and who have the time to give the experiments a close personal attention.

C. The Effect of Narrow and Wide Rations on the Quality of the Milk.

Many experiments have been published and many opinions expressed relative to the effects of single feeds and feed combinations on the quality of milk. The writer has briefly reviewed the most important of these experiments elsewhere.* W. H. Jordan † has recently also presented a most excellent review and critical examination of such experiments.

Practically all of the experiments thus far made have taught that feeds have but very little influence on the quality of milk. By "affecting the quality" is meant the increasing and decreasing of any or all of the solid constituents of the milk, such as casein, albumin, milk sugar, fat and ash. It is a commonly recognized fact that some feeds affect the flavor of milk, and to a slight extent its color, also possibly its acidity and alkalinity. It is possible that feeds and feed combinations rich in fat have a tendency to slightly increase the percentage of fat in the milk of some cows. Whether or not feeds rich in protein have a similar tendency, is still uncertain. It is probable that this increase is only of a temporary character, the milk gradually coming back to its normal condition. Animals very thin in flesh and insufficiently fed, if brought into good condition by proper feed, will probably show an increase in one or all of the solid constituents. This improvement will certainly not be very marked. It is possible that the improvement in the milk brought about by the more complete nourishment of a thin and insufficiently fed animal consists more in an improvement in the *quality* of the fat, or nitrogenous matter, than in increasing to any marked degree their actual percentages in the milk. The quality of milk varies, as is well known, during the different stages of lactation, but this is entirely independent of the influence of feed.

In conducting experiments of this character the investigator should be very careful that he is able to control all the conditions liable to in any way affect the results. The milk-

* Twelfth report of Massachusetts Experiment Station, 1894.

† Agriculture of Maine, 1895, page 139.

producing organs are largely under the control of the nervous system, and any sudden change disturbing the nervous temperament of the animal, such as a sudden extreme change of temperature, an angry man, change of milkers, etc., is very likely to have an effect on the quality of her product. This can easily be observed by testing the milk daily and noting the variations, especially in the percentage of fat. Too short periods render such experiments valueless, as well as changing the entire daily character of the feed in two or three parts of a single experiment. No greater mistake can be made than in employing cheap, unreliable help. The results of many of the experiments thus far made along this line of investigation are of absolutely no value, because one or several improper influences have not been controlled by the experimenter.

In the two experiments which follow, the experimenter has sought as far as possible to prevent any influence other than the one desired to have any bearing on the results. The methods have been described under A. The complete feeding record of each cow will be found at the end of this article.

TABLE V. — *Showing Composition of the Milk.*

		COWS.																	
		ADA (1).						UNA * OR GUERNSEY † (2).						BESSIE (3).					
		Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat.	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat.
EXPERIMENT I.	Narrow ration,	12.92	-	-	4.24	8.68	1:2.05	14.34	-	-	4.53	9.81	1:2.17	13.34	-	-	4.36	8.98	1:2.06
		12.83	-	-	4.07	8.76	1:2.15	14.50	-	-	4.68	9.82	1:2.10	13.37	-	-	4.36	9.01	1:2.07
		13.03	-	-	4.11	8.92	1:2.17	13.78	-	-	4.15	9.63	1:2.32	13.10	-	-	4.22	8.88	1:2.10
	Average,	12.93	-	-	4.14	8.79	1:2.12	14.21	-	-	4.45	9.75	1:2.20	13.27	-	-	4.31	8.96	1:2.08
	Wide ration,	13.13	-	-	3.96	9.17	1:2.32	13.54	-	-	4.12	9.42	1:2.29	12.82	-	-	4.22	8.60	1:2.04
		13.30	-	-	4.20	9.10	1:2.17	13.87	-	-	4.35	9.52	1:2.19	12.60	-	-	4.22	8.36	1:1.97
		13.14	-	-	4.22	8.92	1:2.11	14.25	-	-	4.82	9.43	1:1.96	12.88	-	-	4.16	8.72	1:2.10
	Average,	13.19	-	-	4.13	9.06	1:2.20	13.89	-	-	4.43	9.46	1:2.14	12.77	-	-	4.21	8.56	1:2.04
EXPERIMENT II.	Narrow ration,	13.28	.497	3.11	4.26	9.02	1:2.12	14.50	.511	3.19	5.35	9.15	1:1.71	13.58	.509	3.18	4.78	8.80	1:1.84
		13.11	.493	3.08	4.41	8.70	1:1.97	14.30	.503	3.14	5.39	8.91	1:1.67	13.36	.508	3.17	4.58	8.78	1:1.92
		13.24	.497	3.11	4.25	8.99	1:2.11	14.25	.501	3.13	5.25	9.00	1:1.71	13.55	.522	3.26	4.60	8.95	1:1.95
	Average,	13.21	.496	3.10	4.31	8.90	1:2.07	14.35	.505	3.15	5.33	9.02	1:1.70	13.50	.513	3.20	4.65	8.85	1:1.90
	Wide ration,	13.41	.510	3.18	4.31	9.10	1:2.11	14.48	.526	3.29	5.30	9.18	1:1.73	13.98	.518	3.23	4.88	9.10	1:1.86
		13.49	.511	3.19	4.49	9.00	1:2.01	14.43	.499	3.11	5.53	8.90	1:1.61	14.21	.498	3.11	5.28	8.93	1:1.79
		13.50	.512	3.20	4.41	9.09	1:2.06	14.62	.508	3.17	5.63	8.99	1:1.60	14.05	.489	3.05	5.07	8.98	1:1.77
	Average,	13.47	.511	3.19	4.40	9.07	1:2.06	14.51	.511	3.19	5.49	9.02	1:1.65	14.08	.502	3.13	5.08	9.00	1:1.80

* In Experiment I.

† In Experiment II.

TABLE V. — *Concluded.*

		COWS.																	
		BEAUTY (4).						RED (5).						SPOT (6).					
		Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat.	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat
EXPERIMENT I.	Narrow ration, .	13.98	-	-	4.75	9.23	1:1.94	12.68	-	-	4.02	8.66	1:2.15	14.15	-	-	5.00	9.15	1:1.83
		14.68	-	-	5.19	9.49	1:1.83	12.86	-	-	4.18	8.68	1:2.08	14.17	-	-	4.81	9.36	1:1.94
		14.80	-	-	5.32	9.48	1:1.78	12.58	-	-	3.90	8.68	1:2.23	14.68	-	-	5.30	9.38	1:1.77
	Average, . .	14.40	-	-	5.09	9.40	1:1.85	12.71	-	-	4.03	8.68	1:2.15	14.33	-	-	5.04	9.29	1:1.84
	Wide ration, .	14.92	-	-	5.11	9.81	1:1.92	11.33	-	-	2.85	8.48	1:2.98	14.35	-	-	4.79	9.56	1:2.00
		14.89	-	-	5.13	9.76	1:1.90	11.10	-	-	2.97	8.13	1:2.74	14.80	-	-	5.22	9.58	1:1.83
		14.64	-	-	4.98	9.66	1:1.95	12.33	-	-	4.05	8.28	1:2.05	14.00	-	-	4.85	9.15	1:1.89
	Average, . .	14.82	-	-	5.07	9.75	1:1.92	12.33	-	-	4.05	8.28	1:2.05	14.38	-	-	4.95	9.43	1:1.91
EXPERIMENT II.	Narrow ration, .	14.63	.563	3.52	5.19	9.44	1:1.82	13.33	.468	2.92	4.95	8.38	1:1.69	13.33	.579	3.62	4.89	8.44	1:1.72
		14.62	.559	3.49	5.17	9.45	1:1.82	13.11	.522	3.26	4.39	8.72	1:1.98	14.36	.578	3.61	4.82	9.54	1:1.98
		14.68	.572	3.57	5.24	9.44	1:1.80	13.40	.511	3.19	4.62	8.78	1:1.90	14.34	.588	3.67	4.75	9.59	1:2.02
	Average, . .	14.64	.565	3.53	5.20	9.44	1:1.81	13.28	.500	3.12	4.65	8.63	1:1.86	14.01	.582	3.63	4.82	9.19	1:1.91
	Wide ration, .	14.92	.546	3.41	5.42	9.50	1:1.75	12.93	.455	2.84	4.37	8.56	1:1.96	14.67	.559	3.49	5.34	9.33	1:1.75
		14.95	.547	3.42	5.44	9.51	1:1.75	12.70	.472	2.95	4.21	8.49	1:2.02	14.96	.579	3.62	5.59	9.37	1:1.68
		14.80	.552	3.45	5.19	9.61	1:1.85	13.21	.468	2.92	4.62	8.59	1:1.86	14.81	.595	3.72	5.33	9.48	1:1.78
	Average, . .	14.89	.548	3.43	5.35	9.54	1:1.78	12.95	.465	2.90	4.40	8.55	1:1.95	14.81	.584	3.61	5.42	9.39	1:1.74

In judging the above results, it must not be forgotten that the entire lot of cows was not fed *at the same time* on either the wide or the narrow ration. For example, in Experiment I. cows I., IV. and VI. were first fed the narrow ration; while cows II., III. and V. were having at the same time the wide ration. It would be expected that cows I., IV. and VI. would naturally show slightly higher percentages on the wide ration, *because it was fed later;* and for a like reason cows II., III. and V. would show higher percentages on the narrow ration. In case of Cow V., on the wide ration, it has already been explained that the first two composite samples of milk show low solids, and less than 3 per cent. of fat. In the third sample both the solids and fat very noticeably increased. It is evident that this sudden change was not caused by feed; first, because the animal was in excellent flesh at the beginning of the experiment; and, second, because the change was a permanent one. The cow had been calved but a few weeks, and for some reason had not come to her average quality of milk. It was therefore considered advisable, in the wide ration, to omit in the average the first two analyses. With this exception, the first experiment shows very little variation in the quality of the milk. In the second experiment, cows I., II. and VI. were first fed the narrow ration, and cows III., IV. and V. first received the wide ration. All but Cow II. being somewhat advanced in the period of lactation, it is natural that at least cows I. and VI. should show slightly higher percentages with the wide ration, and cows III., IV. and V. with the narrow ration. This natural tendency is noticed in cows I., II., IV., V. and VI. One can therefore draw more reliable conclusions when the results from the six cows are averaged, thus eliminating as much as possible the error caused by natural shrinkage.

TABLE VI. — *Average Results from 6 Cows.*

Experiment I.

	Average Weight of Animals (Pounds).	Daily Digestible Nutrients consumed.					Composition of Milk.			
		Protein (Pounds).	Fat (Pounds).	Carbohydrates (Pounds).	Total Nutrients (Pounds).	Nutritive Ratio.	Total Solids (Per Cent.).	Nitrogenous Matter (Per Cent.)	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Narrow ration,	941	3.07	.59	10.23	14.06	1:3.86	13.66	-	4.51	9.15
Wide ration,	938	1.46	.52	12.45	14.43	1:9.43	13.56	-	4.47	9.09
Percentage increase narrow over wide.	-	-	-	-	-	-	+.73	-	+.89	+.66

Experiment II.

	Average Weight of Animals (Pounds).	Protein (Pounds).	Fat (Pounds).	Carbohydrates (Pounds).	Total Nutrients (Pounds).	Nutritive Ratio.	Total Solids (Per Cent.).	Nitrogenous Matter (Per Cent.)	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Narrow ration,	899	2.85	.65	9.96	13.46	1:4.04	13.83	3.29	4.83	9.00
Wide ration,	890	1.45	.54	11.44	13.42	1:8.85	14.12	3.24	5.02	9.10
Percentage increase narrow over wide.	-	-	-	-	-	-	−2.10	+1.52	−3.93	−1.11

The average weights of the animals during both periods of each experiment are practically identical. In the first experiment the milk appears to have suffered no change in composition. In the second experiment the wide ration seems to have slightly increased the solids and fat and diminished the nitrogenous matter. This is more strikingly brought out in Table VII.

TABLE VII. — *Showing Percentages on Basis of 14 Per Cent. Solids.*

	Experiment I.		Experiment II.		
	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Nitrogenous Matter (Per Cent.)	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Narrow ration,	4.62	9.38	3.33	4.88	9.11
Wide ration,	4.61	9.39	3.21	4.97	9.02
Percentage increase narrow over wide,	±	±	+3.60	−1.84	+ .99

In Table VII. it will be noticed that the wide ration, containing 1.45 pounds of digestible protein, .54 pound of digestible fat and 11.44 pounds of digestible carbohydrates, seemed to have produced a slight but noticeable increase in the percentage of fat; and the narrow ration, containing 2.85 pounds of digestible protein, .65 pound of digestible fat and 9.96 pounds of digestible carbohydrates, a slight increase in the total nitrogenous matter.

Recognizing the many serious difficulties in the way of securing results that will show *only* the influence of feed or feed constituents in the composition of milk, the writer would of course draw no positive conclusions, but simply present the figures as the results of two carefully conducted experiments along this line of investigation.

COMPLETE DATA OF EXPERIMENTS.

TABLE VIII. — *Total Feeds consumed, and Total Yield and Cost of Milk and Butter.*

Experiment I. Narrow Ration.

COW.	Feeds consumed.					Milk and Butter produced.				Cost of Milk and Butter.			
						Milk.		Butter.					
	Hay (Pounds).	Sugar Beets (Pounds).	Wheat Bran (Pounds).	Chicago Gluten Meal (Pounds).	Corn Meal (Pounds).	Total (Pounds).	Average Daily Yield (Pounds).	Total Butter Fat (Pounds).	Equal to Butter (Pounds).	Total Cost of Feeds consumed.	Cost of Feed per 100 Pounds of Milk (Cents).	Cost per Pound Butter Fat (Cents).	Cost per Pound Butter (Cents).
Ada,	312	312	78	130	-	655.2	25.2	27.13	31.65	$5 28	80.6	19.46	16.68
Una,	364	312	78	156	-	592.4	22.8	26.36	30.76	5 96	100.6	22.61	19.37
Bessie,	390	312	78	156	-	813.6	31.3	35.07	40.91	6 16	75.7	17.56	15.05
Beauty,	468	312	78	156	-	631.2	24.3	32.13	37.48	6 74	106.8	20.97	17.99
Red,	416	312	78	156	-	777.6	29.9	31.34	36.56	6 35	81.6	20.26	17.37
Spot,	416	312	78	156	-	771.5	29.7	38.87	45.35	6 35	82.4	16.32	14.00
Wide Ration.													
Ada,	338	312	78	-	130	559.3	21.5	23.10	26.95	$5 09	90.9	22.03	18.88
Una,	390	312	78	-	156	559.4	21.5	24.78	28.91	5 70	101.9	23.00	19.71
Bessie,	416	312	78	-	156	719.2	27.7	30.28	35.33	5 89	81.9	19.45	16.67
Beauty,	494	312	78	-	156	522.5	20.1	26.48	30.89	6 48	124.1	24.50	21.00
Red,	442	312	78	-	156	761.7	29.3	25.13	29.30	6 09	80.0	24.26	20.80
Spot,	442	312	78	-	156	573.9	22.1	28.41	33.14	6 09	106.1	21.44	18.38

TABLE IX. — *Total Feeds consumed, and Total Yield and Cost of Milk and Butter.*

Experiment II. Narrow Ration.

COW.	FEEDS CONSUMED.					MILK AND BUTTER PRODUCED.				COST OF MILK AND BUTTER.			
						MILK.		BUTTER.					
	Hay (Pounds).	Millet and Soy-bean Ensilage (Pounds).	Wheat Bran (Pounds).	Chicago Gluten Meal (Pounds).	Old-process Linseed Meal (Pounds).	Total (Pounds).	Average Daily Yield (Pounds).	Total Butter Fat (Pounds).	Equal to Butter (Pounds).	Total Cost of Feeds consumed.	Cost of Feed per 100 Pounds of Milk (Cents).	Cost per Pound Butter Fat (Cents).	Cost per Pound Butter (Cents).
Ada,	189	420	42	63	31.5	474.9	22.6	20.47	23.88	$3 63	76.4	17.70	15.90
Guernsey,	210	630	63	63	42	617.4	29.4	32.91	38.39	4 48	72.6	13.62	11.66
Bessie,	210	630	63	63	42	593.2	28.2	27.58	32.20	4 48	75.5	16.23	13.91
Beauty,	220	630	63	63	42	459.4	21.9	23.89	27.87	4 56	99.3	19.10	16.34
Red,	220	630	63	63	42	556.8	26.5	25.90	30.21	4 56	81.9	17.60	15.10
Spot,	220	630	63	63	42	559.0	26.6	26.94	31.43	4 56	81.5	16.93	14.52

Wide Ration.

COW.	Hay (Pounds).	Millet and Soy-bean Ensilage (Pounds).	Wheat Bran (Pounds).	*Corn Meal.*	Old-process Linseed Meal (Pounds).	Total (Pounds).	Average Daily Yield (Pounds).	Total Butter Fat (Pounds).	Equal to Butter (Pounds).	Total Cost of Feeds consumed.	Cost of Feed per 100 Pounds of Milk (Cents).	Cost per Pound Butter Fat (Cents).	Cost per Pound Butter (Cents).
Ada,	189	420	31.5	105	-	402.1	19.5	17.70	20.65	$3 34	83.1	18.87	16.21
Guernsey,	210	630	42	126	-	512.7	24.4	28.15	32.84	4 17	81.3	14.84	12.71
Bessie,	210	630	42	126	-	508.1	24.2	25.81	30.11	4 17	82.1	16.16	13.85
Beauty,	220	630	42	126	-	439.7	20.9	23.53	27.45	4 25	96.6	18.90	15.51
Red,	220	630	42	126	-	553.6	26.4	24.37	28.42	4 25	76.7	17.41	15.00
Spot,	220	630	42	126	-	461.3	22.0	25.00	29.17	4 25	92.2	17.00	14.55

TABLE X. — *Daily Feeds consumed.*

Experiment I. Narrow Ration.

COW.	Feeds consumed (Pounds) per Day. Hay.	Sugar Beets.	Wheat Bran.	Chicago Gluten Meal.	Corn Meal.	Dry Matter consumed per Day (Pounds).	Digestible Protein (Pounds).	Digestible Fat (Pounds).	Digestible Carbohydrates (Pounds).	Total Digestible Nutrients (Pounds).	Nutritive Ratio of Ration.	Weight at Beginning and End of Experiment (Pounds).	Average Weight (Pounds).
Ada, ...	12	12	3	5	-	19.24	2.66	.51	8.85	12.02	1:3.80	788-810	794
Una, ...	14	12	3	6	-	21.85	3.08	.58	10.00	13.66	1:3.72	870-900	905
Bessie, ...	15	12	3	6	-	22.75	3.12	.59	10.39	14.10	1:3.80	869-874	860
Beauty, ...	18	12	3	6	-	25.41	3.24	.63	11.59	15.46	1:4.03	1,037-1,055	1,038
Red, ...	16	12	3	6	-	23.59	3.16	.61	10.77	14.54	1:3.90	1,040-1,058	1,061
Spot, ...	16	12	3	6	-	23.65	3.16	.61	10.79	14.56	1:3.90	1,000-1,008	987

Wide Ration.

COW.	Hay.	Sugar Beets.	Wheat Bran.	Chicago Gluten Meal.	Corn Meal.	Dry Matter consumed per Day (Pounds).	Digestible Protein (Pounds).	Digestible Fat (Pounds).	Digestible Carbohydrates (Pounds).	Total Digestible Nutrients (Pounds).	Nutritive Ratio of Ration.	Weight at Beginning and End of Experiment (Pounds).	Average Weight (Pounds).
Ada, ...	13	12	3	-	5	20.13	1.29	.45	10.68	12.42	1:9.16	805-801	807
Una, ...	14.50	12	3	-	6	22.30	1.40	.51	11.91	13.82	1:9.40	894-884	888
Bessie, ...	16	12	3	-	6	23.67	1.46	.53	12.53	14.52	1:9.50	890-862	867
Beauty, ...	19	12	3	-	6	26.22	1.57	.56	13.57	15.70	1:9.54	1,045-1,033	1,044
Red, ...	17	12	3	-	6	24.55	1.50	.54	12.93	14.97	1:9.52	1,020-1,038	1,025
Spot, ...	17	12	3	-	6	24.48	1.50	.54	12.88	14.92	1:9.49	1,010-982	995

TABLE XI. — *Daily Feeds consumed.*

Experiment II. Narrow Ration.

COW.	Feeds consumed Daily (Pounds).						Dry Matter consumed Daily (Pounds).	Digestible Matter consumed Daily (Pounds).				Nutritive Ratio of Ration.	Weight at Beginning and End of Experiment (Pounds).	Average Weight (Pounds).
	Hay.	Millet and Soy-bean Ensilage.	Wheat Bran.	Chicago Gluten Meal.	Linseed Meal.	Corn Meal.		Protein.	Fat.	Carbohydrates.	Total Nutrients.			
Ada, ...	9	20	2	3	1.5	-	17.43	2.41	.52	8.05	10.98	1:3.9	770-762	763
Guernsey, ...	10	30	3	3	2	-	21.49	2.89	.66	9.88	13.43	1:4.0	862-860	861
Bessie, ...	10	30	3	3	2	-	22.15	2.93	.67	10.21	13.81	1:4.0	835-822	828
Beauty, ...	11	30	3	3	2	-	23.05	2.98	.68	10.65	14.31	1:4.1	995-975	981
Red, ...	11	30	3	3	2	-	23.05	2.98	.68	10.65	14.31	1:4.1	1,022-1,022	1,017
Spot, ...	11	30	3	3	2	-	22.37	2.98	.67	10.32	13.97	1:4.1	948-940	943

Wide Ration.

Ada, ...	9	20	1.5	-	-	5	17.63	1.20	.44	9.58	11.22	1:8.90	775-770	772
Guernsey, ...	10	30	2	-	-	6	21.80	1.50	.56	11.74	13.80	1:8.76	850-835	838
Bessie, ...	10	30	2	-	-	6	21.12	1.44	.55	11.41	13.40	1:8.88	814-835	824
Beauty, ...	11	30	2	-	-	6	22.00	1.49	.56	11.85	13.90	1:8.89	970-966	958
Red, ...	11	30	2	-	-	6	22.00	1.49	.56	11.85	13.90	1:8.89	1,011-1,007	1,004
Spot, ...	11	30	2	-	-	6	22.70	1.55	.57	12.18	14.30	1:8.78	940-945	942

TABLE XII. — *Showing Total Amount of Dry and Digestible Matter consumed, and Total Milk Products produced.*

Experiment I.

CHARACTER OF RATION.	Dry Matter consumed (Pounds).	Digestible Matter consumed (Pounds).	Milk produced (Pounds).	Milk Solids produced (Pounds).	Milk Fat produced (Pounds).
Narrow,	3,549.0	2,193.4	4,241.5	579.4	191.3
Wide,	3,675.4	2,251.1	3,695.5	501.1	165.2

Experiment II.

Narrow,	2,721.6	1,696.0	3,261.0	451.0	157.5
Wide,	2,671.2	1,691.0	2,877.0	406.2	144.4

TABLE XIII. — *Showing for Every 100 Pounds of Dry and Digestible Matter consumed, Amounts of Milk, Milk Solids and Milk Fat produced.*

Narrow Ration.

ONE HUNDRED POUNDS.	EXPERIMENT I.			EXPERIMENT II.		
	Milk (Pounds).	Milk Solids (Pounds).	Fat (Pounds).	Milk (Pounds).	Milk Solids (Pounds).	Fat (Pounds).
Dry matter produced,	119.51	16.32	5.39	119.8	16.6	5.8
Digestible matter produced,	193.41	26.42	8.72	192.3	26.6	9.3

Wide Ration.

Dry matter produced,	100.28	13.74	4.48	107.7	15.4	5.40
Digestible matter produced,	164.16	22.28	7.34	170.1	24.0	8.54

TABLE XIV. — *Pounds of Digestible Matter required to produce 100 Pounds of Milk, a Pound of Milk Solids and a Pound of Butter.*

Narrow Ration.

POUNDS REQUIRED OF —	Experiment I.			Experiment II.		
	TO PRODUCE —			TO PRODUCE —		
	100 Pounds Milk.	One Pound Milk Solids.	One Pound Butter.	100 Pounds Milk.	One Pound Milk Solids.	One Pound Butter.
Digestible matter, ...	51.7	3.78	9.83	52.0	3.76	9.2

Wide Ration.

Digestible matter, ...	60.9	4.49	11.68	58.8	4.16	10.04

TABLE XV. — *Composition of Feeds (Dry Matter).*

Experiment I.

	Hay (Per Cent.).	Digestion Coefficients.	Sugar Beets (Per Cent.).	Digestion Coefficients.	Millet and Soy-bean Ensilage (Per Cent.).	Digestion Coefficients.	Wheat Bran (Per Cent.).	Digestion Coefficients.	Chicago Gluten Meal (Per Cent.).	Digestion Coefficients.	Old-process Linseed Meal (Per Cent.).	Digestion Coefficients.	Corn Meal (Per Cent.).	Digestion Coefficients.	Waste (Cow II., Wide Ration).*
Ash,	6.02	-	9.16	-	-	-	5.77	-	1.16	-	-	-	1.48	-	5.10
Fiber,	33.13	47	8.58	-	-	-	11.63	22	3.12	-	-	-	2.06	-	43.66
Fat,	2.66	53	.63	-	-	-	5.64	71	5.96	98	-	-	4.46	92	1.58
Protein,	9.73	45	8.65	62	-	-	19.20	78	42.73	89	-	-	11.36	60	6.21
Extract matter,	48.47	60	72.98	98	-	-	57.76	68	47.03	93	-	-	80.69	93	43.45

Experiment II.

	Hay (Per Cent.).	Digestion Coefficients.	Sugar Beets (Per Cent.).	Digestion Coefficients.	Millet and Soy-bean Ensilage (Per Cent.).	Digestion Coefficients.	Wheat Bran (Per Cent.).	Digestion Coefficients.	Chicago Gluten Meal (Per Cent.).	Digestion Coefficients.	Old-process Linseed Meal (Per Cent.).	Digestion Coefficients.	Corn Meal (Per Cent.).	Digestion Coefficients.	Waste (Cow II., Wide Ration).*
Ash,	5.32	-	-	-	10.55	-	6.41	-	.90	-	4.94	-	1.27	-	-
Fiber,	32.27	60	-	-	36.07	69	11.03	22	3.63	-	7.26	50	2.44	-	-
Fat,	2.72	49	-	-	4.25	72	5.62	71	6.06	93	7.05	89	4.12	92	-
Protein,	9.21	59	-	-	12.01	57	18.87	78	39.75	89	41.99	89	11.36	60	-
Extract matter,	50.48	59	-	-	37.12	59	58.07	68	49.66	93	38.76	78	80.80	93	-

* Amounting to 14.75 pounds and containing 85 per cent. of dry matter.

TABLE XVI. — *Dry Matter Determinations.*

Experiment I.

	Hay (Per Cent.).	Sugar Beets (Per Cent.).	Millet and Soy-bean Ensilage (Per Cent.).	Wheat Bran (Per Cent.).	Chicago Gluten Meal (Per Cent.).	Old-process Linseed Meal (Per Cent.).	Corn Meal (Per Cent.).
October 24 to November 19,	87.5	13.00	–	88.3	91.0	–	87.7
November 28 to December 24,	87.0	14.70	–	88.6	91.0	–	87.7

Experiment II.

	Hay (Per Cent.).	Sugar Beets (Per Cent.).	Millet and Soy-bean Ensilage (Per Cent.).	Wheat Bran (Per Cent.).	Chicago Gluten Meal (Per Cent.).	Old-process Linseed Meal (Per Cent.).	Corn Meal (Per Cent.).
January 27 to February 17,	88 0	–	18.4	88.0	91.0	90.0	84.5
February 29 to March 21,	91.0	–	19.7	88.0	91.0	90.0	84.5

Market Cost of Feed Stuffs per Ton.

	Experiment I.	Experiment II.
Hay,	$15 00	$15 00
Sugar beets,	5 00	--
Millet and soy-bean ensilage,	–	4 00
Wheat bran,	17 00	16 00
Chicago gluten meal,	23 00	22 00
Linseed meal,	–	22 00
Corn meal,	17 00	16 00

FEEDING EXPERIMENTS WITH PIGS.

(*b*) Rice Meal *v.* Corn Meal.

Experiment I. — *Nov. 12, 1895, to Feb. 11, 1896.*

Results.

Three pigs fed rice meal and skim-milk each showed an average weight of 67 pounds at the beginning of the experiment and 195.2 pounds at the end of the experiment; the three fed corn meal and skim-milk each showed an average weight of 65 pounds at the beginning and 193.5 pounds at the end of the experiment.

The rice meal lot consumed during the experiment 3,519 pounds of skim-milk (1,614 quarts), together with 867 pounds of rice meal, and gained 385 pounds of live weight, equal to 298 pounds of dressed weight; the corn meal lot consumed like quantities of milk and corn meal, and gained 385 pounds of live weight, equal to 309 pounds of dressed weight.

The rice meal lot consumed 1,118.64 pounds of dry matter and the corn meal lot 1,105.65 pounds of dry matter.

The rice meal lot required 2.91 pounds of dry matter to produce 1 pound of live weight and 3.77 pounds to produce 1 pound of dressed weight; the corn meal lot required 2.91 pounds of dry matter to produce 1 pound of live weight and 3.59 pounds to produce 1 pound of dressed weight.

The average daily gain in live weight of each pig in both the rice and corn meal lots was 1.41 pounds.

The three pigs fed rice meal showed an average shrinkage of 22.64 per cent. in dressing; the corn meal fed pigs shrank 20 per cent.

The above results indicate that a good quality of rice meal has a feeding value equal to a similar quality of corn meal.

With grain at $18 per ton and dressed pork at 5 cents per pound, skim-milk returned ½ of a cent per quart, or 23 cents

per 100 pounds; with the same price for grain and dressed pork at 6 cents per pound, skim-milk would return 31.5 cents per 100 pounds.

With grain at $18 per ton and skim-milk at 15 cents per 100 pounds, live weight would cost 2.88 cents per pound and dressed weight 3.66 cents. If skim-milk were reckoned at 25 cents per 100 pounds, live weight would cost 4 cents per pound and dressed weight 5 cents per pound.

Details of the Experiment.

The object of the experiment was to compare the nutritive effect of rice meal with corn meal when fed in connection with skim-milk. Six pigs, grade Chester White, all out of the same litter, were selected. They were received October 15, when six weeks old, and kept for a month before beginning the experiment. Before starting the experiment each pig was placed in a separate pen, of about 100 feet area. The pens were separated by heavy galvanized wire, thus securing good ventilation, and allowing at the same time the animals to see each other. While they had no outdoor run, the pens were large, the room airy and well lighted, and the constant good health of the animals indicated no disturbing influences. Only in very severe weather did the temperature in the building fall a little below freezing.

Feeding.—The animals were fed three times daily, the slightly warmed milk being measured, and the grain ration for the twenty-four hours accurately weighed. The pigs were each given from 5 to 6 quarts of milk daily. At the beginning of the experiment 4 ounces of grain were given with each quart of milk; and the amount increased from time to time, to suit the appetites of the animals. The feed was consumed during the entire time, without a single refusal.

Feeds. — The skim-milk was tested occasionally, and 9.75 per cent. of solids were used in calculating the amount of dry matter it contained. Rice meal is fed and highly prized in Europe. It is occasionally found in our markets, but the present low price of corn meal excludes it. In preparing rice for human consumption, various mechanical processes are employed. After the hull is removed, the rice is

brought into mortars holding from 4 to 6 bushels each and pounded, to remove the yellow, gluey covering of the grain and give it the creamy color so much desired. This pounding really removes the chaff and some of the flour, and leaves the grain but little broken. The rice is then polished to give it a pearly lustre, which is effected by friction of the grains of rice against tanned moose hide. That portion rubbed off is termed rice polish. The chaff and flour above referred to, and in some cases the polish also, are mixed and sold as rice meal for cattle feeding.

Composition.

[Figures equal percentages or pounds per 100.]

	Rice Meal.	Corn Meal.
Water,	10.50	12.00
Ash,	7.67	1.42
Fiber,	5.03	1.84
Fat,	12.10	3.34
Protein,	12.95	9.68
Extract matter,	51.75	71.72

The above feeds have the same type of composition, being comparatively low in protein and high in carbohydrates. They both may be termed heat-producing and fattening feeds. The rice meal contains more fat and less extract or starchy matter than the corn meal.

Data of the Experiment (Nov. 12, 1895, to Feb. 12, 1896).

LOT I — *Rice Meal*

NUMBER OF PIG.	Skim-milk consumed. Quarts.	Skim-milk consumed. Pounds.	Skim-milk consumed. Dry Matter (Pounds).	Grain consumed. Corn Meal (Pounds).	Grain consumed. Rice Meal (Pounds).	Grain consumed. Dry Matter (Pounds).	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Loss of Weight in Dressing (Per Cent.).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Dressed Weight at End of Experiment (Pounds).	Gain in Dressed Weight (Pounds).	Dry Substance used to produce One Pound Live Weight (Pounds).	Dry Substance used to produce One Pound Dressed Weight (Pounds).
I, ...	538	1,172.8	114.35	-	288.87	258.5	67.25	187.00	119.75	1.32	22.86	51.88	144.25	92.37	3.11	4.04
II, ...	538	1,172.8	114.35	-	288.87	258.5	67.25	199.25	132.00	1.45	23.46	51.47	152.50	101.03	2.82	3.69
III., ...	538	1,172.8	114.35	-	288.87	258.5	67.00	200.25	132.25	1.46	21.59	52.53	157.00	104.47	2.80	3.57
Total, . . .	1,614	3,518.5	343.05	-	866.60	775.6	201.50	586.50	385.00	4.23	-	155.88	453.75	297.81	-	-
Average per pig, .	538	1,172.8	114.35	-	288.87	258.5	67.00	195.20	128.30	1.41	22.64	51.96	151.28	99.37	2.91	3.77

LOT II. — *Corn Meal.*

NUMBER OF PIG.	Skim-milk consumed. Quarts.	Skim-milk consumed. Pounds.	Skim-milk consumed. Dry Matter (Pounds).	Grain consumed. Corn Meal (Pounds).	Grain consumed. Rice Meal (Pounds).	Grain consumed. Dry Matter (Pounds).	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Loss of Weight in Dressing (Per Cent.).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Dressed Weight at End of Experiment (Pounds).	Gain in Dressed Weight (Pounds).	Dry Substance used to produce One Pound Live Weight (Pounds).	Dry Substance used to produce One Pound Dressed Weight (Pounds).
I., ...	538	1,172.8	114.35	288.87	-	254.20	67.00	192.50	125.50	1.38	19.74	53.77	154.50	100.73	2.94	3.66
II., ...	538	1,172.8	114.35	288.87	-	254.20	58.75	184.50	125.75	1.41	20.73	46.57	146.25	99.68	2.93	3.70
III., ...	538	1,172.8	114.35	288.87	-	254.20	69.25	203.50	134.25	1.48	19.41	55.81	164.00	108.19	2.74	3.41
Total, . . .	1,614	3,518.5	343.05	866.60	-	762.60	195.00	580.50	385.50	4.27	-	156.15	464.75	308.60	-	-
Average per pig, .	538	1,172.8	114.35	288.87	-	254.20	65.00	193.50	128.50	1.42	19.96	52.05	154.92	102.90	2.90	3.59

Additional Data.

In order to throw light on the price returned for skim-milk and the cost of feed required to produce a pound of live and dressed weight, the following additional data is presented, and the amount of feed consumed is reckoned from October 15, when the pigs were received, to February 12, when they were slaughtered. The results below are based on the entire lot of six pigs.

	Quarts.	Pounds.
Total milk consumed by six pigs,	4,092	8,921
Total grain consumed by six pigs,	-	1,920
Live weight actually gained,	-	968
Dressed weight actually gained,	-	762

PRICE RETURNED FOR SKIM-MILK.	WHEN CORN MEAL SELLS AT $18 PER TON AND DRESSED PORK AT —				WHEN CORN MEAL SELLS AT $24 PER TON AND DRESSED PORK AT —			
	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.
Per quart (fraction of cent),	.50	.69	.87	1.06	.36	.54	.73	.91
Per 100 pounds (cents),	23.00	31.50	40.00	48.50	16.00	25.00	33.00	42.00

The pigs were six weeks old when they were received, and weighed about 33 pounds each. When slaughtered they averaged 194.5 pounds each. The pigs made a rapid growth, and the results are fully as favorable as could be hoped for.

Cost of Feed per Pound of Growth produced (Cents).

	Live Weight.	Dressed Weight.
When corn meal costs $18 per ton and milk ¼ cent per quart,	2.88	3.66
When corn meal costs $18 per ton and milk ½ cent per quart,	4.00	5.00
When corn meal costs $24 per ton and milk ¼ cent per quart,	3.48	4.43
When corn meal costs $24 per ton and milk ½ cent per quart,	4.55	5.80

(c) Oat Feed v. Corn Meal for Pigs.

Experiment II. — *March 29 to June 30, 1896.*

Results.

Four pigs fed oat feed and skim-milk each showed an average weight of 42.56 pounds at the beginning and 136.75 pounds at the end of the experiment; the two fed corn meal and milk showed an average weight of 45.25 pounds at the beginning and 157.70 pounds at the end of the experiment.

The oat feed lot consumed during the experiment 5,389 pounds of skim-milk (2,474 quarts), together with 869 pounds of oat feed, and gained 376.75 pounds of live weight, an average gain of 94.19 pounds each; the corn meal lot consumed 2,694.5 pounds of milk (1,236 quarts), together with 435 pounds of corn meal, and gained 225.25 pounds, or an average gain of 112.62 pounds.

The oat feed lot consumed 1,305.96 pounds of dry matter and required 3.47 pounds of dry matter to produce a pound of live weight; the corn meal lot consumed 645.1 pounds of dry matter and required 2.86 pounds of dry matter to produce a pound of live weight.

The oat feed lot showed an average daily gain of 1.03 pounds in live weight, and the corn meal lot a daily gain of 1.22 pounds in live weight.

The present experiment shows that only 83.6 per cent. as much pork was produced with oat feed as with an equal weight of corn meal, or 100 pounds of corn meal were equal to 120 pounds of oat feed.

With corn meal at $18 per ton, oat feed at $16 per ton and dressed pork at 5 cents per pound, skim-milk returned ⅓ of a cent per quart, or 15.6 cents per 100 pounds in case of the entire lot of six pigs.

With the same price for grain and skim-milk reckoned at ¼ cent per quart, live weight would cost 3.34 cents and dressed weight 4.3 cents per pound. Further details concerning prices will be found in the description of the experiment.

Details of Experiment II.

The object of this experiment was to compare the nutritive effect of corn meal with oat feed. Six grade Chester White pigs, all from the same litter, were used. The pigs were kept in the same pens and handled in the same way as described in the previous experiment. They had been in the pens over a month before the experiment began.

Feeding.— The pigs were each fed at the beginning 5 quarts of milk together with 3 ounces of meal to each quart of milk, and increased in this proportion till 8 quarts of milk were fed; the grains were then still further increased from time to time to satisfy the appetites of the animals.

Feeds.— The skim-milk and corn meal were of the same average quality as reported in the previous experiment. Oat feed is the refuse from factories engaged in the preparation of oat meal for human consumption. It consists of the poor oats, oat hulls and some of the bran and starch which are removed in the process of manufacture. It is, as the corn meal, a heat-producing rather than a flesh-forming feed. Oat feed varies very much in composition, and consequently in feeding value. The sample used may be considered an average one.

Composition.

[Figures equal percentages or pounds per 100.]

	Oat Feed.	Corn Meal.
Water,	10.00	12.00
Ash,	5.00	1.42
Fiber,	14.75	1.84
Fat,	3.72	3.34
Protein,	12.19	9.68
Extract matter,	54.34	71.72

The presence of the high percentage of fiber in the oat feed is indicative of a considerable amount of hulls.

Data of the Experiment (March 29 to June 30, 1896).

LOT I. — *Oat Feed.*

NUMBER OF PIG.	Skim-milk consumed.			Grains consumed.			Live Weight at Beginning of Experiment (Pounds).	Live Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Dry Matter needed to produce a Pound of Live Weight (Pounds).
	Quarts.	Pounds.	Dry Matter (Pounds).	Oat Feed (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).					
I.,	618	1,347.24	131.36	217.3	-	195.13	46.75	140.75	94.00	1.02	3.47
II.,	618	1,347.24	131.36	217.3	-	195.13	35.75	121.75	86.00	.94	3.89
III.,	618	1,347.24	131.36	217.3	-	195.13	43.50	143.75	100.25	1.09	3.26
IV.,	618	1,347.24	131.36	217.3	-	195.13	44.25	140.75	96.50	1.05	3.38
Total,	2,472	5,388.96	525.44	869.2	-	780.52	170.25	547.00	376.75	-	-
Average per pig,	618	1,347.24	131.36	217.3	-	195.13	42.56	136.75	94.19	1.03	3.50

LOT II. — *Corn Meal.*

NUMBER OF PIG.	Quarts.	Pounds.	Dry Matter (Pounds).	Oat Feed (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).	Live Weight at Beginning of Experiment (Pounds).	Live Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Dry Matter needed to produce a Pound of Live Weight (Pounds).
V.,	618	1,347.24	131.36	-	217.3	191.20	43.25	154.57	111.50	1.21	2.89
VII.,	618	1,347.24	131.36	-	217.3	191.20	47.25	160.75	113.75	1.24	2.84
Total,	1,236	2,694.48	262.72	-	434.6	382.40	90.50	315.50	225.25	-	-
Average per pig,	618	1,347.24	131.36	-	217.3	191.20	45.25	157.70	112.62	1.22	2.86

Additional Data.

In order to show the price returned for skim-milk and the cost of feed required to produce a pound of live and dressed weight, the additional data is presented for the six pigs: —

	Quarts.	Pounds.
Total milk consumed by six pigs,	3,708	8,083.5
Total oat feed consumed by six pigs,	–	869.0
Total corn meal consumed by six pigs,	–	435.0
Live weight actually gained,	–	602.0
Dressed weight calculated,	–	470.0

PRICE RETURNED FOR SKIM-MILK.	WITH OAT FEED AT $16 PER TON, CORN MEAL AT $18 PER TON AND DRESSED PORK AT —				WITH OAT FEED AT $21 PER TON, CORN MEAL AT $24 PER TON AND DRESSED PORK AT —			
	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.
Per quart (fraction of cent),	.34	.47	.60	.72	.25	.37	.50	.62
Per 100 pounds (cents),	15.60	21.40	27.00	33.00	11.00	17.00	23.00	29.00

The pigs did not grow as rapidly as in the first experiment, and consequently the returns are below those obtained with the previous lot. The animals seemed inferior, and unable to turn the feed into rapid growth. The above figures are more nearly what might be expected by the average farmer.

Cost of Feed per Pound of Growth produced (Cents).

	Live Weight.	Dressed Weight.
With grain prices at $16 and $18 and milk at ¼ cent per quart,	3.34	4.30
With grain prices at $16 and $18 and milk at ½ cent per quart,	4.88	6.25
With grain prices at $21 and $24 and milk at ¼ cent per quart,	3.90	5.00
With grain prices at $21 and $24 and milk at ½ cent per quart,	5.46	7.00

(*d*) Digestion Experiments with Sheep.

We have continued our digestion studies of the various cattle feeds during the past year. Some of the work undertaken is as yet incomplete, and experiments are still in progress. Below is presented the digestion coefficients obtained with several feed stuffs. The entire data will be presented at another time. By digestion coefficients is meant the percentage of the several groups of constituents composing feed stuffs that the animal is capable of digesting. Thus, if wheat bran contains 16 per cent. of protein, or 16 pounds in 100, and the coefficient of the protein digestibility is 78, this means that the animal can digest 78 per cent. of the 16 pounds, or 12.48 pounds.

Digestion Coefficients obtained.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Fiber (Per Cent.).	Fat (Per Cent.).	Protein (Per Cent.).	Extract Matter (Per Cent.).
Rice meal,	1	2	74	(?)	91	62	92
Pope gluten feed,	1	2	87	77	81	86	90
Pope gluten meal,	1	2	93	(?)	98	84	88
Millet and soy-bean ensilage,	1	4	59	69	72	57	59
Corn and soy-bean ensilage,	1	3	69	65	82	65	75
Hay (mostly timothy),	1	2	55	57	57	54	55

Compilation of Analyses of Fodder Articles and Dairy Products,

MADE AT

AMHERST, MASS.

1868-1897.

Prepared by E. B. Holland.

A. Fodder Articles.

B. Fertilizing Ingredients in Fodders.

C. Dairy Products.

A. *Compositon and Digestibility of Cattle Feeds.*

[Figures equal percentages or pounds in 100.]

NAME.	Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
I. Green Fodders.																			
Corn fodder,	33	75.	1.2	5.2	0.5	2.0	16.1	20.8	2.0	8.0	64.4	2.7	0.4	1.1	12.1	10.6	1.6	4.3	48.3
Sorghum,	6	83.	1.2	4.6	0.3	1.5	9.4	27.0	1.8	8.8	55.3	2.7	0.2	0.7	7.0	15.9	1.3	4.0	41.0
Common millet,	9	65.	1.7	11.0	1.0	2.6	18.7	31.4	2.9	7.4	53.4	-	-	-	-	-	-	-	-
Japanese millet (*Panicum italicum*),	12	75.	1.5	7.8	0.5	2.1	13.1	31.2	2.0	8.2	52.5	-	-	-	-	-	-	-	-
Panicum miliaceum,	1	69.	1.7	8.2	1.2	1.8	18.1	26.5	3.8	5.8	58.4	-	-	-	-	-	-	-	-
Barn-yard millet (*Panicum crus-galli*),	2	75.	1.9	7.0	0.6	2.4	13.1	27.9	2.5	9.7	52.2	-	-	-	-	-	-	-	-
Summer rape,	1	86.	2.6	2.5	0.5	2.0	6.4	17.8	3.6	14.3	45.7	-	-	-	-	-	-	-	-
Winter rape,	1	86.	3.1	1.7	0.5	2.1	6.6	12.1	3.6	15.0	47.1	-	-	-	-	-	-	-	-
Dwarf Essex rape,	1	86.	2.2	2.7	0.6	1.8	6.7	19.3	4.3	12.9	47.8	-	-	-	-	-	-	-	-
Green oats,	6	74.	2.1	7.8	0.8	3.6	11.7	30.0	3.1	13.8	45.0	4.4	0.5	2.5	8.5	16.8	1.9	9.7	32.9
Green barley,	1	79.	1.8	7.9	0.6	2.7	8.0	37.6	2.8	12.9	38.1	4.4	0.4	1.9	5.8	21.1	1.7	9.0	27.8
Green rye,	2	72.	1.6	8.9	0.6	2.1	14.8	31.8	2.1	7.5	52.9	5.0	0.4	1.5	10.8	17.8	1.3	5.3	38.6
Timothy,	2	65.	1.7	11.3	0.7	3.2	18.1	32.3	2.0	9.1	51.7	5.9	0.4	1.5	11.4	16.8	1.2	4.4	32.6

Hungarian grass,	2	74.	2.1	7.0	0.5	2.6	13.8	26.9	1.9	10.0	53.1	4.8	0.3	1.6	9.1	18.3	1.0	6.2	35.0
Vetch and oats (1 to 1),	1	82.	1.7	5.4	0.5	3.0	7.4	30.0	2.8	16.7	41.1	-	-	-	-	-	-	-	-
Vetch and oats (1 to 4),	1	79.	1.9	6.3	0.8	2.8	9.2	30.0	3.8	13.3	43.8	-	-	-	-	-	-	-	-
Peas and oats,	2	84.	1.3	4.7	0.5	2.4	7.1	29.4	3.1	15.0	44.4	2.8	0.2	1.8	4.3	17.6	1.4	11.6	27.1
Barley and peas,	1	84.	1.3	5.4	0.5	2.2	6.6	33.8	3.1	13.8	41.2	3.2	0.2	1.7	4.0	20.3	1.4	10.6	29.1
Horse bean,	1	85.	0.9	4.3	0.4	2.5	6.9	28.6	2.7	16.7	46.0	-	-	-	-	-	-	-	-
Flat pea,	2	79.	1.9	5.2	0.9	6.1	6.9	24.8	4.3	29.0	32.9	-	-	-	-	-	-	-	-
Cow pea,	3	82.	1.7	3.9	0.7	3.1	8.6	21.7	3.9	17.2	47.8	-	-	-	-	-	-	-	-
Soy bean,	14	76.	2.5	6.5	1.1	4.2	9.7	27.1	4.6	17.5	40.4	3.7	0.3	3.0	6.7	16.5	1.3	12.4	27.9
Soy bean (early white),	4	70.	3.9	6.7	0.8	5.0	13.6	22.3	2.7	16.7	45.3	-	-	-	-	-	-	-	-
Soy bean (medium green),	1	70.	3.9	7.1	1.2	5.8	12.0	23.7	4.0	19.3	40.0	-	-	-	-	-	-	-	-
Soy bean (medium black)	2	75.	3.1	5.9	1.3	4.7	10.0	23.4	5.2	18.9	39.9	-	-	-	-	-	-	-	-
Soy bean (late),	4	74.	3.5	5.5	0.7	5.9	10.4	21.1	2.7	22.7	40.0	-	-	-	-	-	-	-	-
Bokhara or sweet clover,	3	79.	2.1	6.3	0.6	4.2	7.8	30.0	2.9	20.0	37.1	-	-	-	-	-	-	-	-
Serradella,	3	82.	1.9	5.3	0.4	2.6	7.8	29.5	2.2	14.4	43.3	-	-	-	-	-	-	-	-
Common vetch,	2	82.	1.5	5.5	0.4	2.7	7.9	30.6	2.2	15.0	43.9	-	-	-	-	-	-	-	-
Hairy vetch,	1	82.	1.5	5.7	0.2	3.6	7.0	31.6	1.1	20.0	38.9	-	-	-	-	-	-	-	-
Kidney vetch,	1	81.	2.6	2.9	0.7	3.5	9.3	15.3	3.7	18.4	48.9	-	-	-	-	-	-	-	-
Prickly comfrey,	1	87.	2.8	1.5	0.3	2.3	6.1	11.5	2.4	17.7	46.9	-	-	-	-	-	-	-	-
Spurry,	1	72.	2.6	7.0	0.1	2.9	15.4	25.0	0.4	10.3	55.0	-	-	-	-	-	-	-	-
Scotch tares,	1	82.	2.2	5.1	0.3	3.5	6.9	28.3	1.7	19.5	38.3	-	-	-	-	-	-	-	-

A. Composition and Digestibility of Cattle Feeds — Continued.

NAME.	Analyses.	Composition. Fresh or Air-Dry Substance. Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Water-Free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Digestibility. Fresh or Air Dry Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Water-Free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
II. Ensilages.																			
Corn ensilage,	39	78.	1.2	6.0	0.8	1.9	12.1	27.3	3.6	8.6	55.0	4.1	0.6	1.0	8.0	18.6	2.8	4.6	37.9
Corn and soy-bean ensilage,	4	76.	2.4	7.2	0.8	2.5	11.1	30.0	3.3	10.4	46.3	4.7	0.7	1.6	8.3	19.5	2.7	6.8	34.7
Millet ensilage,	3	74.	2.4	7.5	0.8	1.7	13.6	28.8	3.1	6.5	52.3	-	-	-	-	-	-	-	-
Millet and soy-bean ensilage,	9	79.	2.8	7.2	1.0	2.8	7.2	34.3	4.8	13.3	34.3	-	-	-	-	-	-	-	-
Apple-pomace ensilage,	1	85.	0.6	3.3	1.1	1.2	8.8	22.0	7.3	8.0	58.7	-	-	-	-	-	-	-	-
III. (a) Hay and Dry Coarse Fodders.																			
Corn fodder,	4	20.	4.1	23.4	1.4	6.2	44.9	29.2	1.7	7.7	56.3	15.2	1.0	3.7	33.2	19.0	1.3	4.5	41.7
Corn stover,	30	20.	4.7	28.3	1.1	5.9	40.0	35.4	1.4	7.3	50.0	19.0	0.6	3.1	25.6	23.7	0.7	3.8	32.0
English hay (mixed grasses),	66	14.	5.3	26.9	2.4	8.1	43.3	31.3	2.8	9.4	50.3	16.1	1.2	4.8	25.5	18.8	1.4	5.5	29.7
Fermented hay,	1	14.	6.3	25.4	2.2	8.4	43.7	29.5	2.6	9.8	50.8	-	-	-	-	-	-	-	-
Canada hay,	4	14.	4.6	28.1	2.1	6.1	45.1	32.7	2.4	7.1	52.4	14.6	1.3	2.9	28.4	17.0	1.4	3.4	33.0
Rowen,	15	17.	5.9	22.2	3.0	10.5	41.4	26.7	3.6	12.7	49.9	14.7	1.4	7.2	26.9	17.6	1.7	8.8	32.4

Timothy, ...	6	14.	4.2	28.3	1.9	8.5	43.1	32.9	2.2	9.9	50.1	14.7	1.1	4.1	27.2	17.1	1.3	4.8	31.6
Red-top, ...	4	14.	4.3	28.3	1.4	6.8	45.2	32.9	1.6	7.9	52.6	17.3	0.7	4.1	24.4	20.1	0.8	4.8	32.6
Kentucky blue-grass, ...	2	14.	7.2	29.7	1.8	7.5	39.8	34.5	2.1	8.7	46.3	-	-	-	-	-	-	-	-
Orchard grass, ...	4	14.	6.1	30.0	2.5	8.1	39.3	34.9	2.9	9.4	45.7	19.2	1.4	4.9	21.4	22.3	1.6	5.6	25.6
Meadow fescue, ...	5	14.	7.9	31.7	1.6	5.8	39.0	36.9	1.9	6.7	45.3	-	-	-	-	-	-	-	-
Perennial rye-grass, ...	4	14.	7.9	25.4	2.1	10.1	40.5	29.5	2.4	11.8	47.1	-	-	-	-	-	-	-	-
Italian rye-grass, ...	4	14.	6.5	28.6	1.6	7.1	42.2	33.2	1.9	8.4	49.0	-	-	-	-	-	-	-	-
Hungarian grass, ...	1	14.	4.9	27.5	1.9	8.2	43.5	31.9	2.3	9.5	50.6	18.7	1.2	4.9	29.1	21.7	1.5	5.7	33.9
Barn-yard grass, ...	1	14.	8.6	29.0	1.7	13.1	33.6	33.7	2.0	15.2	39.1	-	-	-	-	-	-	-	-
Black grass (salt) (*Juncus Gerardi*), . .	2	16.	7.7	24.4	2.4	6.8	42.7	29.0	2.9	8.1	50.8	14.6	1.0	4.3	23.9	17.4	1.2	5.1	28.4
High-grown salt hay (largely *spartina juncea*).	1	16.	7.0	22.2	2.1	6.3	46.4	26.4	2.5	7.5	55.3	11.1	1.0	4.0	21.6	13.2	1.2	4.7	29.3
Branch grass (salt) (largely *spartina juncea*),	1	16.	8.8	22.3	1.8	7.0	44.1	26.6	2.2	8.3	52.4	11.6	0.6	4.3	23.8	13.8	0.7	5.1	28.3
Low meadow fox grass (salt) (*spartina juncea*).	1	16.	5.4	22.3	2.2	6.0	48.1	26.5	2.6	7.2	57.3	11.4	0.5	3.0	25.0	13.5	0.6	4.1	29.8
Salt hay (variety unknown), . . .	2	16.	4.3	24.0	2.5	3.4	49.8	28.6	3.0	4.0	59.3	-	-	-	-	-	-	-	-
Swamp or swale hay, ...	2	14.	5.8	26.7	1.9	7.1	44.5	31.0	2.2	8.3	51.8	8.8	0.8	2.4	20.5	10.2	1.0	2.8	23.8
Vetch and oats (1 to 1), ...	1	14.	8.1	25.8	2.4	14.4	35.3	30.0	2.8	16.7	41.1	-	-	-	-	-	-	-	-
Vetch and oats (1 to 4), ...	1	14.	7.8	25.8	3.3	11.4	37.7	30.0	3.8	13.3	43.8	17.0	2.6	6.8	20.4	19.8	3.0	8.0	23.7
Vetch and barley, ...	2	14.	5.3	27.9	2.0	11.9	38.9	32.4	2.3	13.8	45.2	18.4	1.6	7.1	21.0	21.4	1.8	8.3	24.4
Oats in bloom, ...	1	15.	5.6	30.6	2.4	5.5	40.9	36.0	2.8	6.5	48.1	17.1	1.5	3.9	29.9	20.2	1.7	4.6	35.1
Oats in milk, ...	1	15.	5.2	29.2	2.3	9.3	39.0	34.4	2.7	10.9	45.9	16.4	1.4	6.5	28.5	19.3	1.7	7.6	33.5
Oats, ripe, ...	1	15.	5.3	30.9	2.2	5.2	41.4	36.4	2.6	6.1	48.7	-	-	-	-	-	-	-	-
Winter rye in bloom, ...	1	15.	5.4	28.1	2.2	9.1	40.2	33.0	2.6	10.7	47.3	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	Composition: Fresh or air-dry substance.						Composition: Water-free substance.				Digestibility: Fresh or air-dry substance.				Digestibility: Water-free substance.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
III. (a) Hay and Dry Coarse Fodders — Con.																			
Barley in milk,	1	15.	4.2	24.7	2.4	8.8	44.9	29.0	2.8	10.4	52.8	13.8	1.5	6.2	32.8	16.2	1.7	7.3	38.5
Common millet,	6	15.	4.3	28.3	1.8	6.6	44.0	33.3	2.1	7.8	51.8	-	-	-	-	-	-	-	-
Japanese millet,	3	15.	4.7	30.1	1.8	5.1	43.3	35.4	2.1	6.0	50.9	-	-	-	-	-	-	-	-
III. (b) Legumes.																			
Mammoth red clover,	5	15.	8.1	24.4	1.8	13.1	37.6	28.7	2.1	15.4	44.2	-	-	-	-	-	-	-	-
Medium red clover,	4	15.	7.3	26.0	2.4	11.8	37.5	30.6	2.7	13.9	44.1	12.0	1.3	6.5	24.0	14.1	1.4	7.6	28.2
Alsike clover,	8	15.	9.8	23.1	2.1	14.0	36.0	27.2	2.5	16.5	42.4	12.2	1.1	9.2	25.6	14.4	1.3	10.9	30.1
Lucerne (alfalfa),	6	15.	6.8	26.1	1.6	11.6	38.9	30.7	1.9	13.6	45.8	11.2	0.8	8.0	28.0	13.2	0.9	9.4	33.0
Sand lucerne,	1	15.	8.3	18.0	2.2	13.9	42.6	21.2	2.6	16.4	50.0	-	-	-	-	-	-	-	-
English gray pea,	1	15.	8.2	25.7	2.7	17.5	30.9	30.2	3.2	20.6	36.4	-	-	-	-	-	-	-	-
Canada beauty pea,	1	15.	6.7	24.7	2.3	18.7	37.6	29.0	2.7	16.1	44.3	-	-	-	-	-	-	-	-
Sainfoin,	1	15.	7.3	20.4	3.0	14.8	39.5	24.0	3.5	17.4	46.5	-	-	-	-	-	-	-	-

III. (c) Straw.																			
Wheat straw,	1	15.	4.1	30.5	1.4	6.2	42.8	35.9	1.6	7.3	50.4	15.9	0.4	0.7	16.3	18.7	0.5	0.8	19.2
Barley straw,	2	15.	4.8	32.2	2.5	6.5	39.0	37.9	2.9	7.7	45.9	18.0	1.1	1.3	21.1	21.2	1.2	1.5	24.8
Millet straw,	1	15.	5.8	35.5	1.2	4.2	38.3	41.8	1.4	4.9	45.1	–	–	–	–	–	–	–	–
Straw (*P. crus-galli*),	1	15.	4.6	30.4	2.1	5.2	42.7	35.8	2.5	6.1	50.2	–	–	–	–	–	–	–	–
Straw (*P. miliaceum*),	1	15.	5.2	35.9	2.5	3.3	38.1	42.2	3.0	3.9	44.8	–	–	–	–	–	–	–	–
Straw (*P. Italicum*),	1	15.	5.3	35.2	1.4	3.6	39.5	41.4	1.7	4.2	46.5	–	–	–	–	–	–	–	–
Soy-bean straw,	3	15.	6.1	36.1	1.8	4.7	36.3	42.5	2.1	5.5	42.7	13.7	0.1	2.4	24.0	16.2	1.3	2.8	28.2
Horse-bean straw,	1	15.	8.1	35.2	1.3	8.3	32.1	41.4	1.5	9.8	37.8	13.7	0.7	4.1	20.5	16.1	0.8	4.8	24.2
III. (d) Miscellaneous.																			
Teosinte,	1	15.	6.0	24.5	1.1	8.2	45.2	28.8	1.3	9.6	53.2	–	–	–	–	–	–	–	–
Sulla,	2	15.	7.9	17.6	2.3	14.5	42.7	20.7	2.7	17.1	50.2	–	–	–	–	–	–	–	–
Hairy lotus,	2	15.	7.0	16.8	2.5	12.6	46.1	19.8	3.0	14.8	54.2	–	–	–	–	–	–	–	–
White daisy,	1	15.	6.0	30.7	2.0	6.6	39.7	36.1	2.4	7.8	46.7	14.1	1.2	3.8	26.6	16.6	1.5	4.5	31.3
Carrot tops,	1	15.	11.8	11.6	1.7	18.0	41.9	13.6	2.0	21.2	49.3	–	–	–	–	–	–	–	–
IV. Roots, Tubers, Fruits, etc.																			
Beets, red,	7	88.	1.1	0.7	0.1	1.5	8.6	5.8	0.8	12.5	71.7	0.5	0.1	1.4	8.6	4.3	0.4	11.4	71.7
Beets, sugar,	12	86.	0.8	0.9	0.1	1.5	10.7	6.4	0.7	10.7	76.5	0.7	0.1	1.4	10.7	4.8	0.4	9.7	76.5
Beets, yellow fodder,	4	89.	1.0	1.0	0.2	1.3	7.5	9.1	1.8	11.8	68.2	0.8	0.1	1.2	7.5	6.8	0.9	10.7	68.2
Mangolds,	5	88.	1.2	0.8	0.1	1.4	8.5	6.7	0.8	11.7	70.8	0.6	0.1	1.3	8.5	5.0	0.4	10.6	70.8
Turnips,	5	90.	0.9	1.2	0.2	1.1	6.6	12.0	2.0	11.0	66.0	0.9	0.2	1.0	6.4	9.0	2.0	9.9	64.0

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance				Fresh or Air dry Substance.				Water-free Substance			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen free Extract.	Cellulose.	Fat.	Protein.	Nitrogen free Extract.	Cellulose.	Fat.	Protein.	Nitrogen free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
IV. Roots, Tubers, Fruits, etc. — Con.																			
Ruta-bagas,	3	89.	1.1	1.3	0.2	1.2	7.2	11.8	1.8	10.9	65.5	1.0	0.2	1.0	6.8	8.8	1.5	8.7	62.2
Carrots,	5	89.	0.9	1.1	0.2	1.0	7.8	10.0	1.8	9.1	70.9	-	-	-	-	-	-	-	-
Parsnips,	1	80.	1.5	1.5	0.7	1.3	15.0	7.5	3.5	6.5	75.0	-	-	-	-	-	-	-	-
Potatoes,	14	81.	1.0	0.5	0.1	1.9	15.5	2.6	0.5	10.0	81.6	-	-	0.8	14.1	-	-	4.4	74.2
Artichokes,	1	78.	1.1	0.9	0.2	2.9	16.9	4.1	0.9	13.1	76.9	-	-	-	-	-	-	-	-
Apples,	2	78.	0.7	1.5	0.5	1.0	18.3	6.8	2.3	4.5	83.2	-	-	-	-	-	-	-	-
Apple pomace,	3	83.	0.4	2.9	0.8	1.2	11.7	17.0	4.7	7.1	68.8	-	-	-	-	-	-	-	-
Sugar-beet pulp,	1	90.	0.1	2.5	0.1	1.4	5.9	25.0	1.0	14.0	59.0	-	-	-	-	-	-	-	-
Cranberries,	1	89.	0.2	1.2	0.6	0.5	8.5	10.9	5.5	4.5	77.3	-	-	-	-	-	-	-	-
Japanese radish (*merinia*),	1	93.	0.7	0.7	0.1	0.5	5.0	10.0	1.4	7.1	71.5	-	-	-	-	-	-	-	-
Japanese radish (*niyas-hige*),	1	93.	0.7	0.7	0.1	0.5	5.0	10.0	1.4	7.1	71.5	-	-	-	-	-	-	-	-
V. Grains, Seeds, etc.																			
Corn kernels,	29	10.6	1.5	1.9	4.8	10.9	70.3	2.1	5.3	12.2	78.8	-	-	-	-	-	-	-	-
Sweet corn kernels,	1	12.0	1.4	2.1	8.4	11.1	65.0	2.4	9.5	12.6	73.9	-	-	-	-	-	-	-	-

Wheat kernels,	3	10.6	1.8	2.2	1.7	12.4	71.3	2.5	1.9	13.9	79.7	-	-	-	-	-	-	-	-
Oat kernels,	3	10.8	3.0	8.5	5.5	13.6	58.6	9.5	6.2	15.3	65.6	1.8	3.9	11.7	43.4	2.0	4.4	13.6	48.5
Broom-corn seed,	1	14.1	2.2	7.1	3.5	9.6	63.5	8.3	4.0	11.2	73.9	-	-	-	-	-	-	-	-
Soy beans,	4	13.0	5.1	5.0	17.2	31.2	28.5	5.7	19.8	35.8	32.8	2.5	14.6	28.1	20.5	2.8	16.8	32.2	23.6
Red adzinki beans,	2	15.9	3.5	3.9	0.7	20.6	55.4	4.7	0.8	24.4	65.9	-	-	-	-	-	-	-	-
Saddle beans,	1	12.4	5.4	4.2	14.5	13.2	50.3	4.8	16.5	15.1	57.4	-	-	-	-	-	-	-	-
Horse beans,	1	10.3	3.9	7.3	0.9	26.9	50.7	8.1	1.0	30.0	56.5	5.3	0.8	23.7	47.2	5.8	0.9	26.4	52.5
Millet seed,	3	13.3	2.6	7.7	3.7	11.4	61.3	8.9	4.3	13.2	70.6	-	-	-	-	-	-	-	-
Barn-yard millet seed (*P. crus-galli*),	1	10.3	3.1	7.7	5.7	12.3	60.9	8.6	6.3	13.7	67.7	-	-	-	-	-	-	-	-
Chestnuts,	1	44.9	1.5	1.4	8.0	7.3	36.9	2.5	14.5	13.3	67.0	-	-	-	-	-	-	-	-
VI. Flour and Meal.																			
Corn meal,	40	13.6	1.4	1.9	3.4	9.6	70.1	2.2	3.9	11.1	81.1	-	3.1	5.8	65.2	-	3.6	6.7	75.4
Corn and cob meal,	37	10.5	1.4	6.7	3.7	9.0	68.7	7.5	4.1	10.0	76.8	3.0	3.0	0.5	60.5	3.4	3.4	5.2	67.5
Cooked feed (oats and corn),	1	5.5	3.8	8.2	5.0	14.0	63.5	8.6	5.0	14.8	67.6	-	-	-	-	-	-	-	-
Ground wheat,	1	11.5	2.0	2.9	2.0	12.1	69.5	3.3	2.2	13.7	78.6	-	-	-	-	-	-	-	-
Ground oats,	2	9.3	3.5	8.5	3.6	11.4	63.7	9.4	4.0	12.6	70.2	1.7	3.0	8.9	48.4	1.9	3.3	9.9	53.4
Ground barley,	5	13.1	2.4	5.7	1.9	11.3	65.6	6.5	2.2	13.0	75.6	2.9	1.7	7.9	64.0	3.3	2.0	9.1	69.6
Broom-corn meal,	1	13.5	2.1	6.9	3.5	9.7	64.3	8.0	4.1	11.2	74.3	-	-	-	-	-	-	-	-
Pea meal,	1	8.8	2.6	17.7	1.6	19.2	50.1	19.4	1.8	21.0	54.9	4.6	0.9	15.9	47.1	5.0	1.0	1.7	51.6
Peanut meal,	1	8.0	4.0	3.5	10.8	49.0	24.7	3.8	11.8	53.3	26.8	0.8	9.6	44.6	22.7	0.9	10.5	48.5	24.7
"Red dog" flour,	1	9.7	1.9	1.4	4.4	22.6	60.0	1.6	4.9	25.0	66.4	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
VI. Flour and Meal — Concluded.																			
Bean meal,	1	12.0	1.4	2.1	8.5	11.0	65.0	2.4	9.7	12.5	73.8	1.5	7.3	9.7	60.5	1.7	8.3	11.0	68.6
Soy-bean meal,	1	9.2	5.0	3.9	16.3	34.8	30.8	4.3	18.0	38.3	33.9	2.0	13.9	31.3	22.2	2.9	15.3	34.5	24.4
VII. (a) By-products and Refuse.																			
Cotton-seed meal,	36	8.0	6.9	6.7	10.7	42.0	25.7	7.3	11.6	45.6	27.9	2.1	10.0	37.0	16.4	2.3	10.8	40.1	17.9
Cotton-seed meal (meats and hull),	1	7.8	3.6	19.8	6.7	26.4	35.7	21.4	7.2	28.7	38.8	-	-	-	-	-	-	-	-
Linseed meal, old process,*	9	9.7	6.0	7.6	6.6	33.5	36.6	8.4	7.3	37.1	40.5	4.3	5.9	29.8	28.5	4.8	6.5	33.0	31.6
Cleveland linseed meal,	8	8.3	5.0	8.5	2.9	36.1	38.3	9.3	3.2	39.3	41.8	6.3	2.7	30.7	32.2	6.9	3.0	33.4	35.1
Cleveland flax meal,	1	9.9	5.3	7.6	2.5	40.2	34.5	8.4	2.8	44.6	38.3	-	-	-	-	-	-	-	-
Cocoanut meal,	1	9.3	5.2	17.1	11.7	20.5	36.2	18.8	12.9	22.6	40.0	-	-	-	-	-	-	-	-
VII. (b) Gluten Products.																			
Chicago gluten meal, old process,	3	9.2	0.8	1.1	6.2	30.4	52.3	1.2	6.8	33.5	57.6	-	5.8	27.1	48.6	-	6.3	29.8	53.6
Chicago gluten meal, new process,	6	9.2	1.3	2.5	6.1	37.8	43.1	2.8	6.7	41.5	47.4	-	5.7	33.6	40.1	-	6.2	36.9	44.1

King gluten meal,	3	7.7	1.9	1.4	19.0	35.4	34.6	1.5	20.6	38.4	36.4	-	17.9	32.2	27.3	-	19.4	34.9	28.8
Pope gluten meal (cream),	2	8.0	0.6	1.7	10.2	36.2	43.3	1.8	11.1	39.3	47.1	-	10.0	30.4	38.1	-	10.9	33.0	41.4
Iowa gluten meal (golden),	1	4.8	1.2	6.9	12.9	25.7	48.5	7.2	13.5	27.0	51.0	5.4	10.2	21.3	43.7	5.6	10.7	22.4	45.9
Hammond gluten meal,	1	8.2	1.1	1.5	9.7	29.9	49.6	1.6	10.6	32.6	54.0	-	9.0	26.6	46.1	-	9.9	29.0	50.2
Gluten meal (varieties uncertain),	38	9.0	0.9	3.3	8.3	27.3	51.2	3.6	9.1	30.0	56.3	-	7.6	24.3	45.1	-	8.4	26.7	49.5
Buffalo gluten feed,	18	8.2	0.9	6.8	11.5	23.2	49.4	7.4	12.5	25.2	53.6	5.3	9.1	19.3	44.5	5.8	9.9	20.9	48.2
Buffalo gluten feed,†	1	10.5	2.6	6.7	4.4	27.1	48.7	7.5	4.9	30.3	54.4	5.2	3.3	22.5	43.8	5.8	3.9	25.1	49.0
Peoria gluten feed,	8	6.9	0.6	7.4	11.5	21.4	52.2	8.0	12.4	23.0	56.1	5.8	9.1	17.8	47.0	6.2	9.8	19.1	50.5
Pope gluten feed,	2	8.0	1.3	6.3	8.4	25.3	50.7	6.9	9.1	27.5	55.1	4.9	6.6	21.0	45.6	5.4	7.2	22.8	49.6
Diamond gluten feed,	1	8.4	1.1	7.3	10.2	22.0	51.0	8.0	11.1	24.0	55.7	5.7	8.1	18.3	45.9	6.2	8.8	19.9	50.1
Chicago maize feed,	5	8.2	0.6	7.5	7.1	24.9	51.7	8.2	7.7	27.1	56.3	5.4	6.4	20.9	43.9	5.9	6.9	22.8	47.9
Starch feed (Pope),	1	5.5	0.8	14.5	10.7	10.7	57.8	15.2	11.3	11.3	61.3	-	-	-	-	-	-	-	-
Glucose feed (Richardson),	1	6.3	1.0	11.0	11.0	21.6	49.1	11.7	11.7	23.1	52.4	-	-	-	-	-	-	-	-
Corn germ feed,	1	7.5	0.8	13.0	11.3	10.0	57.4	14.1	12.2	10.8	62.0	-	-	-	-	-	-	-	-
Atlas gluten feed,	9	7.5	1.7	11.0	12.6	31.5	35.7	11.9	13.6	34.1	38.6	11.0	11.5	23.0	30.0	11.9	12.4	24.9	32.4
Corn screenings,	1	11.1	2.1	2.9	4.0	7.4	72.5	3.3	4.5	8.3	81.5	-	-	-	-	-	-	-	-
Dried brewer's grain,	5	9.0	3.8	10.6	4.9	22.8	48.9	11.7	5.4	25.1	53.7	5.6	4.5	18.0	28.9	6.2	4.9	19.8	31.7
Wet brewer's grain,	1	77.0	0.7	3.8	2.0	6.7	9.8	16.7	8.5	29.0	42.5	-	-	-	-	-	-	-	-
Malt sprouts,	2	12.0	5.2	12.8	2.6	24.3	43.1	14.6	3.0	27.6	49.0	4.4	2.6	19.4	29.7	5.0	3.0	22.1	33.8

* National Linseed Oil Company.

† Improved process.

A. Composition and Digestibility of Cattle Feeds — Continued.

NAME.	Analyses.	COMPOSITION. Fresh or Air-dry Substance. Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	COMPOSITION. Water-free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	DIGESTIBILITY. Fresh or Air-dry Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	DIGESTIBILITY. Water-free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
VII. (c) Brans and Middlings.																			
Cotton hull bran,	1	11.	1.9	35.0	1.1	2.3	48.7	39.3	1.2	2.6	54.7	-	-	-	-	-	-	-	-
Spring wheat bran,	4	11.	5.7	10.4	5.0	15.9	52.0	11.7	5.6	17.9	58.4	2.5	3.8	12.7	36.4	2.8	4.2	14.3	40.9
Winter wheat bran,	3	11.	6.2	8.5	2.9	15.1	56.3	9.6	3.2	17.0	63.3	2.3	1.9	11.6	36.6	2.6	2.0	13.1	41.1
Wheat bran (average),	53	11.	6.7	9.6	4.5	16.1	52.1	10.8	5.0	18.1	58.5	2.1	3.2	12.6	35.4	2.4	3.6	14.1	39.8
Heavy bran (bran and flour),	2	11.	4.1	7.2	4.5	16.8	56.4	8.1	5.1	18.4	63.4	-	-	-	-	-	-	-	-
Boston mixed feed,	1	11.	4.8	6.3	4.6	19.2	54.1	7.1	5.2	21.6	60.8	-	-	-	-	-	-	-	-
"Imperial mill" mixed feed,	1	11.	3.1	5.1	4.5	15.0	61.3	5.7	5.0	16.9	68.8	-	-	-	-	-	-	-	-
Quincy mixed feed,	1	11.	4.8	6.9	5.1	16.5	55.7	7.8	5.7	18.5	62.6	-	-	-	-	-	-	-	-
Rye bran,	2	11.	4.1	3.5	2.3	15.6	63.5	4.0	2.6	17.8	71.3	-	-	-	-	-	-	-	-
Pea bran,	1	11.	2.9	41.1	1.1	9.2	34.7	46.2	1.2	10.3	39.0	-	-	-	-	-	-	-	-
Louisiana rice bran,	1	11.	9.4	13.3	8.6	8.7	49.0	14.9	9.7	9.8	55.0	-	-	-	-	-	-	-	-
Wheat middlings,	11	11.	5.1	6.6	4.8	15.8	56.7	7.4	5.4	17.8	63.7	23.8	4.1	13.4	49.9	2.7	4.6	15.1	56.1
Rye middlings,	1	11.	3.6	3.3	5.0	11.7	65.4	3.7	5.6	13.2	73.5	-	-	-	-	-	-	-	-

Oat middlings,	1	11.	4.2	17.4	3.3	10.8	53.3	19.5	3.7	12.1	59.9	–	–	–	–	–	–	–	–
Buckwheat middlings,	1	11.	4.8	4.6	6.7	22.7	50.2	5.2	7.5	25.5	56.4	–	–	–	–	–	–	–	–
VII. (d) Miscellaneous.																			
Cotton hulls,	4	11.	2.6	40.2	2.8	5.8	37.6	45.2	3.1	6.5	42.2	18.9	2.2	3.2	12.8	21.2	2.4	3.7	14.3
Cotton-seed feed,	2	10.	3.0	37.6	3.4	10.4	35.6	41.8	3.8	11.6	39.5	–	–	–	–	–	–	–	–
Hominy meal (previous to 1891),	4	8.	2.3	3.9	9.0	9.6	67.2	4.3	9.8	10.4	73.1	–	–	–	–	–	–	–	–
Hominy chop or meal,*	1	7.8	2.9	4.3	9.8	11.8	63.4	4.6	10.6	12.8	68.9	–	–	–	–	–	–	–	–
Cerealine,	2	10.	2.7	5.4	8.9	12.1	60.9	6.0	9.9	13.4	67.7	–	–	–	–	–	–	–	–
Rice meal,	2	10.2	8.1	5.4	13.1	12.0	51.2	6.0	14.6	13.2	57.0	–	11.9	7.4	47.1	–	13.3	8.2	52.4
Excelsior feed,	1	7.1	4.1	13.7	5.0	9.1	61.0	14.7	5.4	9.8	65.7	–	–	–	–	–	–	–	–
Oat feed,	20	7.5	5.0	15.1	4.0	11.1	57.3	16.3	4.3	12.0	61.9	–	–	–	–	–	–	–	–
Proteina,	4	8.4	2.5	10.0	6.6	21.7	50.8	10.9	7.2	23.7	55.5	–	–	–	–	–	–	–	–
Hall's dairy feed,	1	7.2	6.1	10.2	9.5	20.8	46.2	11.0	10.2	22.4	49.8	–	–	–	–	–	–	–	–
Rye feed,	2	8.9	2.7	3.3	2.6	13.8	68.7	3.6	2.9	15.1	75.4	–	–	–	–	–	–	–	–
Peanut feed,	2	10.0	2.6	56.4	5.5	8.9	16.6	62.7	6.1	9.9	18.4	6.8	5.0	6.3	8.1	7.5	5.5	7.0	9.0
Peanut husks,	1	13.0	1.2	66.0	1.7	5.0	13.1	75.9	1.9	5.7	15.1	–	–	–	–	–	–	–	–
Bakery refuse,	1	13.3	10.1	0.3	5.5	8.0	62.8	0.4	6.4	9.2	72.4	–	–	–	–	–	–	–	–
Vinegar mash,	1	94.5	0.2	0.5	0.5	0.9	3.4	8.6	8.5	16.5	63.4	–	–	–	–	–	–	–	–
Refuse from starch works,	1	57.0	0.4	3.2	4.4	9.6	25.4	7.5	10.2	22.4	59.0	–	–	–	–	–	–	–	–
Glucose refuse,	1	6.7	1.1	4.5	9.9	19.7	58.1	4.8	10.6	21.1	62.3	–	–	–	–	–	–	–	–

* Recent analysis.

A. Composition and Digestibility of Cattle Feeds — Concluded.

NAME.	Analyses.	Composition. Fresh or Air-dry Substance. Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Composition. Water Free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Digestibility. Fresh or Air Dry Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Digestibility. Water Free Substance. Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
VII. (d) Miscellaneous — Concluded.																			
Damaged wheat,	1	13.1	2.0	2.7	2.2	14.2	65.8	3.1	2.5	16.3	75.8	-	-	-	-	-	-	-	-
Cocoa dust,	1	7.1	6.3	5.5	24.1	14.4	42.6	5.9	25.9	15.5	45.9	-	-	-	-	-	-	-	-
Broom corn waste,	1	8.7	4.5	35.9	0.9	6.1	43.9	39.3	1.0	6.8	48.0	-	-	-	-	-	-	-	-
Sugar-beet refuse,	1	28.9	5.3	5.8	0.3	8.6	51.1	8.1	0.4	12.1	71.9	-	-	-	-	-	-	-	-
Corn cobs,	6	7.6	1.3	31.4	0.5	2.7	56.5	34.0	0.6	2.9	61.1	20.4	0.3	0.5	33.9	22.1	0.3	0.5	36.7
Palmetto root,	1	11.5	3.9	18.9	0.4	3.4	61.9	21.3	0.5	3.8	70.0	-	-	-	-	-	-	-	-
Ground cloves,	2	12.2	7.4	28.1	2.0	13.2	37.1	32.0	2.3	15.0	42.3	-	-	-	-	-	-	-	-
Calf meal (Blatchford),	1	8.1	4.3	4.6	4.5	25.6	52.9	5.0	4.9	27.8	57.6	-	-	-	-	-	-	-	-
Animal meal (Bowker's),	1	5.1	28.6	-	16.2	40.0	-	-	17.1	42.2	-	-	-	-	-	-	-	-	-

B. Fertilizing Ingredients in Fodder Articles.

[Figures equal percentages or pounds in 100.]

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
I. Green Fodders.						
Corn fodder,	14	79.	.41	.33	.15	$1 45
Sorghum,	7	83.	.23	.23	.09	86
Barn-yard millet (*Panicum crus-galli*),	1	75.	.46	.49	.11	1 69
Japanese millet (*P. Italicum*),	3	63.	.61	.41	.19	2 05
Summer rape,	1	86.	.32	.73	.09	1 60
Green oats,	3	83.	.49	.38	.13	1 67
Green rye,	2	72.	.30	.64	.12	1 47
Hungarian grass,	1	74.	.39	.54	.16	1 62
Vetch and oats,	1	86.	.24	.79	.09	1 45
Horse bean,	1	75.	.68	.35	.08	2 05
Flat pea,	1	79.	1.05	.45	.14	3 10
Cow pea,	1	82.	.32	.18	.10	1 04
Small pea,	1	82.	.48	.37	.11	1 62
Soy bean,	1	73.	.29	.53	.15	1 36
Soy bean (early white),	1	67.	.94	.91	.21	3 36
Soy bean (medium green),	1	70.	.84	.71	.20	2 91
Soy bean (medium black),	1	77.	.80	.57	.18	2 65
Soy bean (late),	1	80.	.60	.68	.14	2 25
Bokhara or sweet clover,	1	79.	.45	.42	.13	1 62
Serradella,	2	83.	.41	.42	.14	1 53
Spring vetch,	1	85.	.36	.45	.10	1 40
Kidney vetch,	1	81.	.56	.35	.09	1 78
Prickly comfrey,	1	87.	.37	.76	.12	1 76
Common buckwheat,	1	85.	.44	.54	.09	1 67
Silver-hull buckwheat,	1	85.	.29	.39	.14	1 21
Japanese buckwheat,	1	85.	.26	.53	.14	1 08
Corn ensilage,	7	80.	.42	.39	.13	1 52
Corn and soy-bean ensilage,	1	71.	.79	.44	.42	2 51
Millet ensilage,	3	74.	.26	.62	.14	1 37
Millet and soy-bean ensilage,	5	76.	.48	.50	.12	1 76
II. Hay and Dry Coarse Fodders.						
Corn fodder,	7	20.	1.53	.77	.47	4 87
Corn stover,	17	20.	.92	1.22	.26	3 66

* Using the figures for the retail cost of nitrogen, phosphoric acid and potash in fertilizers, the amounts obtained show comparative rather than actual values, because the ingredients in fertilizers are easier to handle and in a more available form than in fodders.

B. Fertilizing Ingredients in Fodder Articles — Continued.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
II. Hay and Dry Coarse Fodders — Con.						
English hay,	12	15.	1.27	1.50	.29	$4 81
Rowen,	13	15.	1.70	1.56	.46	6 05
Timothy,	8	15.	1.19	1.40	.33	4 55
Red top,	4	15.	1.06	.94	.33	3 78
Kentucky blue-grass,	2	15.	1.19	1.52	.39	4 73
Orchard grass,	4	15.	1.22	1.58	.38	4 85
Meadow fescue,	6	15.	.92	1.96	.37	4 50
Perennial rye-grass,	2	15.	1.15	1.45	.52	4 68
Italian rye-grass,	4	15.	1.11	1.18	.52	4 32
Salt hay,	1	15.	1.06	.65	.23	3 40
Millet,	1	15.	1.22	1.61	.46	4 95
Vetch and oats,	3	15.	1.23	1.27	.62	4 78
Mammoth red clover,	3	15.	2.14	1.16	.52	6 76
Medium red clover,	2	15.	2.01	2.11	.41	7 30
Alsike clover,	6	15.	2.26	2.10	.63	8 09
Lucerne (alfalfa),	4	15.	1.87	1.32	.48	6 04
Sainfoin,	1	15.	2.54	1.95	.73	8 69
Barley straw,	2	15.	.95	2.03	.19	4 48
Soy-bean straw,	1	15.	.69	1.04	.25	2 92
Millet straw,	1	15.	.68	1.73	.18	3 52
Teosinte,	1	15.	1.32	3.35	.16	6 66
White lupine,	1	15.	2.56	1.46	.29	7 87
Yellow lupine,	1	15.	2.28	2.51	.51	12 57
Spanish moss,	1	15.	.61	.56	.07	2 09
Sulla,	2	15.	2.31	1.96	.42	7 88
White daisy,	1	15.	.26	1.18	.41	2 17
Carrot tops,	1	15.	2.95	4.60	.57	12 19
III. Roots, Tubers, Fruits, etc.						
Beets, red,	8	88.	.24	.44	.09	1 10
Beets, sugar,	4	87.	.22	.48	.10	1 10
Beets, yellow fodder,	1	91.	.19	.46	.09	99
Mangolds,	3	88.	.15	.34	.14	83
Turnips,	4	90.	.17	.38	.12	90
Ruta-bagas,	3	89.	.19	.49	.12	1 03

* See note on page 151.

B. Fertilizing Ingredients in Fodder Articles — Continued.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
III. Roots, Tubers, Fruits, etc. — Con.						
Carrots,	3	89.	.16	.46	.09	$0 93
Parsnips,	1	80.	.22	.62	.19	1 32
Potatoes,	4	80.	.29	.51	.08	1 29
Artichokes,	1	78.	.46	.48	.17	1 74
Apples,	2	80.	.13	.19	.01	51
Apple pomace,	2	81.	.23	.13	.02	70
Cranberries,	1	89.	.08	.10	.03	32
Japanese radish (*merinia*),	1	93.	.08	.28	.05	52
Japanese radish (*niyas hige*),	1	93.	.08	.34	.05	58
IV. Grains, Seeds, etc.						
Corn kernels,	13	10.9	1.82	.40	.70	5 04
Oat kernels,	1	9.0	2.10	–	–	–
Soy bean,	2	18.3	5.30	1.99	1.87	16 39
Red adzinki beans,	1	14.8	3.24	1.54	.94	10 16
White adzinki beans,	1	16.9	3.33	1.48	.97	10 35
Saddle beans,	1	12.3	2.12	2.13	1.52	8 59
Common millet,	2	11.5	2.01	.45	.96	6 02
Japanese millet,	1	13.7	1.73	.38	.69	5 15
Chestnuts,	1	45.0	1.18	.63	.39	3 79
V. Flour and Meal.						
Corn meal,	3	14.1	1.92	.34	.71	5 59
Corn and cob meal,	29	9.0	1.41	.47	.57	4 37
Wheat flour,	2	12.1	2.02	.36	.35	5 52
Ground barley,	1	13.4	1.55	.34	.66	4 65
Pea meal,	1	8.9	3.08	.99	.82	9 12
Soy-bean meal,	1	10.8	5.89	2.23	1.57	17 80
Peanut meal,	1	8.0	7.84	1.54	1.27	21 50
VI. By-products and Refuse.						
Cotton-seed meal,	24	8.2	6.70	1.83	2.47	20 13
Linseed meal (old process),	4	8.0	5.39	1.21	1.78	15 75
Cleveland linseed meal,	5	8.0	5.83	1.25	1.70	16 76
Gluten meal (Chicago),	2	9.6	6.04	.06	.43	14 74
Gluten meal (King),	1	7.8	5.69	.08	.69	14 36
Gluten meal (variety uncertain),	5	8.5	5.09	.05	.42	12 64

* See note on page 151.

B. Fertilizing Ingredients in Fodder Articles — Concluded.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
VI. By-products and Refuse — Con.						
Gluten feed (Buffalo),	5	8.2	3.72	.06	.34	$9 29
Atlas gluten feed,	1	11.2	4.80	.16	.23	11 89
Dried brewers' grain,	2	8.6	3.65	.85	1.05	10 76
Wheat bran,	10	9.9	2.36	1.40	2.10	8 95
Louisiana rice bran,	1	10.3	1.43	.84	1.71	5 81
Wheat middlings,	2	10.2	2.75	.75	1.25	8 48
Rye middlings,	1	12.5	1.84	.81	1.26	6 36
Buckwheat hulls,	1	11.9	.49	.52	.07	1 76
Cotton hulls,	3	10.6	.75	1.08	.18	3 05
Proteina,	1	10.1	2.97	.57	1.00	8 59
Rye feed,	1	9.6	1.95	.98	1.56	7 06
Peanut feed,	2	10.0	1.46	.79	.23	4 50
Peanut husks,	1	13.0	.80	.48	.13	2 52
Damaged wheat,	1	13.1	2.26	.51	.83	6 68
Glucose refuse,	1	6.7	3.37	.09	.61	8 73
Cocoa dust,	1	7.1	2.30	.63	1.34	7 36
Broom corn waste (stalks),	1	10.4	.87	1.86	.46	4 36
Corn cobs,	8	12.1	.50	.60	.06	1 85
Palmetto roots,	1	11.5	.54	1.38	.16	2 82
Meat meal,	1	8.0	11.21	.30	.73	27 86
VII. Dairy Products.						
Buttermilk,	1	91.1	.51	.05	.04	1 31
Skim-milk,	22	90.3	.59	-	-	-
Whey,	1	93.7	.10	.07	.17	47

* See note on page 151.

C. *Analyses of Dairy Products (Per Cent.).*

	Analyses.	Solids.			Fat.			Curd.	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	2,173	18.27	10.20	13.52	7.54	1.72	4.20	3.51 [1]	-	.71 [2]
Skim-milk,	354	10.48	7.68	9.48	1.02	.05	.32	-	-	-
Buttermilk,	31	9.86	6.83	8.33	.38	.11	.27	-	-	-
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	-	-	.62
Cream (concentrated commercial),	2	50.12	48.71	49.41	45.63	32.20	42.33 [3]	-	-	-
Butter (salted),	39	92.89	85.35	89.21	89.05	81.43	84.36	1.17	3.43	-
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	.76	-	-
Whole-milk cheese (Jersey),*	1	-	-	62.84	-	-	37.32	22.13	-	3.39
Whole-milk cheese,*	1	-	-	64.17	-	-	34.34	26.69	-	3.14
Cheese from milk skimmed after twelve hours' standing,*	1	-	-	62.70	-	-	27.81	30.37	-	4.52
Cheese from milk skimmed after twenty-four hours' standing,*	1	-	-	57.76	-	-	23.42	31.99	-	2.35
Cheese from milk skimmed after thirty-six hours' standing,*	1	-	-	56.05	-	-	17.67	33.24	-	5.14
Cheese from milk skimmed after forty-eight hours' standing,*	1	-	-	54.59	-	-	15.77	34.94	-	3.88
Cheese from skim-milk, with addition of buttermilk,*	1	-	-	51.62	-	-	18.35	28.63	-	4.64
Genuine oleomargarine cheese,*	1	-	-	62.10	-	-	31.66	25.94	-	4.50

* From analyses made in 1875: [1] Average of 42 determinations; [2] Average of 8 determinations; [3] Average of 5 determinations.

Tables of the Digestibility of American Feed Stuffs.

Experiments made in the United States.

Compiled by J. B. LINDSEY.

I. Experiments with Ruminants.

II. Experiments with Swine.

Dec. 31, 1896.

TABLES OF THE DIGESTIBILITY OF AMERICAN FEED STUFFS.

I. Experiments with Ruminants.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Hay and Dry Course Fodders.								
Timothy hay (in bloom),	3	5	55.6—65.7 60	56.4—66.8 60	55.8—62.1 58	51.5—61.8 57	50.3—60.4 56	57.5—71.8 63
Timothy hay (past bloom),	5	10	47.0—61.1 53	48.4—62.3 54	37.2—56.8 47	34.6—61.1 53	38.8—50.4 45	55.6—66.9 60
Timothy hay (average all trials),	12	26	57	58	52	60	48	63
Hay of mixed grasses (medium in protein*),	1	2	-	-	49	50	40	58
Hay of mixed grasses (rich in protein),	6	20	54—62 58	- -	56—66 60	44—57 48	56—64 58	56—63 59
Rowen (mixed grasses),	1	4	- -	63—67 65	65—68 66	44—50 46	68—70 69	63—68 65
Rowen (chiefly timothy),	1	4	- -	62—67 64	62—73 66	48—51 49	66—69 68	60—65 63
Average (both samples),	-	-	-	65	66	47	68	64
Salt hay of black grass (*Juncus Gerardi*),	1	2	57—62 60	- -	57—64 60	37—46 41	62—63 63	53—59 56
High-grown salt hay (largely *Spartina juncea*),	1	2	51—55 53	- -	46—55 50	42—51 47	62—63 63	52—55 53
Branch grass (*Spartina juncea*, with *Spartina stricta*, var. *glabra*),	1	2	55—57 56	- -	48—56 52	27—36 31	61—63 62	54—55 54
Low meadow fox grass (*Spartina juncea*),	1	2	52—54 53	- -	49—53 51	17—30 24	- 57	51—52 52

Meadow, swale or swamp hay,	1	2	38—40 39	– –	30—36 33	– 44	31—37 34	– 46
Hay of vetch and oats,	1	2	58—58 58	– –	65—67 66	17—20 19	60—61 60	54—54 54
Clover and timothy hay (poorly cured),	1	2	54.3—55.3 55	– –	52—54.4 53	– 58	37.5—37.9 38	– 60
Hungarian hay,	1	2	64.3—65.8 65	65.9—66.8 66	66.8—68.5 68	– 64	– 60	66.9—67.4 67
Hay of blue-joint grass (past bloom) (*Calamagrostis Canadensis*),	1	1	40	42	37	37	57	43
Hay of blue-joint grass (bloom),	1	2	66.7—70.5 69	68.1—71.5 70	71.5—73.4 72	51.4—53.3 52	68.2—72.3 70	66.4—70.9 69
Hay of orchard grass (ten days after bloom),	1	1	54	56	58	54	59	54
Hay of orchard grass (stage not given),	1	2	57.5—60 59	– –	60—66.7 64	55.4—57.4 56	60—60.8 60	55.3—57.3 56
Average of both samples,	2	3	56	56	61	55	60	55
Hay of red top,	2	3	57.6—62.3 60	59.3—63.6 61	60.8—61.8 61	44.2—58.8 51	60.4—62.4 61	59.1—65.2 62
Dried pasture grass,	1	1	71	–	77	60	72	73
Oat straw,	1	2	49—51.7 50	50.8—53.2 52	57.2—58 58	35.5—41 38	– –	51.8—54.6 53
Barley hay,	1	4	59	62	62	41	65	63
Hay of Legumes.								
Soy-bean hay,	1	2	61.9—62.7 62	– –	59.5—62.1 61	18.7—39.7 29	70.1—72.1 71	66.1—71.5 69
Peanut-vine hay,	1	2	59.5—60.2 60	– –	51.2—52.6 52	62.1—69.8 66	63—63.6 63	69.3—69.7 70

* Below 10 per cent.

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Hay of Legumes — Concluded.								
Cow-pea-vine hay (fair quality),	1	2	– 59	– –	41.2—44.6 43	46.4—53.7 50	63.9—65.1 65	– 71
Clover hay (late bloom, fair quality),	1	2	54.4—55.5 55	55.9—56.4 56	43.8—49 46	51.8—54.8 53	49.3—59.1 55	63.3—64.8 64
Clover hay (good quality),	1	2	50.8—53.5 52	51.6—54.3 53	46.6—49 48	40—48 43	47—52.2 49	56.8—58.9 58
White clover hay (bloom),	1	1	66	67	61	51	73	70
Scarlet clover hay (*T. incarnatum*),	3	9	56.8—65.4 62	52—58 56	32—58.1 45	29—54 44	64—73 69	52—73.6 62
Alsike clover (*T. hybridum*),	2	3	61.1—64.3 62	62—65.2 63	51—58.7 53	35.1—69.3 50	64—69.2 66	66.5—74.1 71
Alfalfa (lucerne) (late bloom),	1	2		–	49	54	77	64
Alfalfa (lucerne) (stage not given),	1	1	–	–	43	48	69	72
Corn Plant (partially Air Dry).								
Corn stover,	1	4	61.1—62 62	– –	64.8—68.3 67	48.1—55.8 52	49.6—54.8 52	62.5—64.5 64
Corn stover (shredded, fed dry),	1	2	57	–	65	72	38—42 40	56
Corn stover (shredded, fed wet),	1	2	59—62 60	– –	69—70 70	73—76 74	33—39 36	57—61 59

Corn stover (average all tests),	3	8	60	-	67	62	45	61
Corn stover (tops and blades),	1	2	59—60.5 60	- -	71.1—71.7 71	70.6—71.9 71	54.2—56.6 55	61.9—62.6 62
Corn stover (leaves of),	1	2	54.8—56.2 56	- -	54.3—67 61	60.6—65.4 63	43.1—68.8 56	57.1—60.6 59
Corn stalk (below ear),	1	2	64—69 67	- -	71—75 74	79—80 80	15—27 21	65—73 69
Topped stover (part above ear),	1	2	52—58 55	- -	69—72 71	62—65 64	17—27 22	50—57 54
Corn husks,	1	2	71—73 72	- -	78—81 80	23—42 33	24—35 30	75 -
Corn leaves (below ear),	1	2	62—67 65	- -	75—80 78	52—59 56	28—41 35	66—70 68
Flint corn fodder (ears just forming),	1	3	69—72 70	71—73 71	72—73 72	63—71 67	69—73 70	71—73 71
Flint (mature) field corn fodder,	4	9	68—73 71	71—75 73	69—80 76	59—77 70	59—79 65	69—78 73
Dent (mature) field corn fodder,	6	14	57—70 66	- -	43—68 57	64—82 76	30—61 48	61—81 72
Average both kinds,	-	-	68	-	65	74	55	73
Dent (in milk) field corn fodder,	5	11	58.8—66 63	- -	50—71 64	67—79 75	44—51 50	61—69 66
Dent (immature, Burrill and Whitman, coarse),	1	4	51—64 57	- -	45—74 59	66—84 76	20—36 27	57—66 61
Dent (immature, no ears formed),	4	8	61—70 65	63—71 67	63—77 71	59—72 66	57—67 62	57—70 64
Sweet corn fodder (mature),	3	6	60—71 67	62—74 70	70—77 74	63—71 74	54—73 64	57—73 68

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Miscellaneous Dry Substances.								
Hay of wild oat grass (*Danthonica spicata*),	2	3	59.6—68.3 64	61.2—69.1 65	65.1—70.6 68	38.2—62.8 50	48.6—68 58	62.1—68.8 65
Hay of witch grass (*Triticum repens*),	2	4	59.9—62.7 61	61—64.3 62	56.4—67.6 62	53.6—60 57	49.5—64.2 58	62.1—69.9 66
Hay of buttercups (*Ranunculus acris*),	1	2	56	57	41	70	56	67
Hay of white weed (*Leucanthemum vulgare*),	1	2	58	58	46	62	58	67
Cats-tail millet (*Pennesetum spicatum*),	1	2	61.1—63.6 62	- -	64.7—68.4 67	44.7—47.6 46	60.6—64.6 63	58.3—60 59
Johnson-grass hay,	1	1	55	-	58	39	45	54
Sorghum fodder (leaves),	1	2	59.9—66.3 63	- -	64.9—75.9 70	46.3—47.1 47	59.5—62.2 61	62.5—66.6 65
Sorghum bagasse,	1	1	61	-	64	46	14	65
Cotton-seed hulls (fed alone),	4	13	35—47.5 41	- -	.54—57.6 47	58.2—89.3 79	.00—24.6 6	12.9—45.7 34
Cotton-seed hulls when fed with cotton-seed meal (7 to 1 and 6 to 1),	1	3	41 -	- -	33—40 38	- 78	- -	48—50 49
Cotton-seed hulls when fed with cotton-seed meal (4 to 1 to 1½ to 1),	3	11	43—48 45	- -	43—50 46	66—80 76	- -	49—57 51
Cotton-seed feed (hulls and meal, 7 to 1 and 6 to 1),	1	3	45—46 46	- -	34—40 37	81—82 82	44—46 45	50—51 50
Cotton-seed feed (hulls and meal, 4 to 1 to 1½ to 1),	3	11	52—56 55	- -	43—49 46	84—86 85	61—65 62	49—56 54

Green Fodders.								
Dent corn fodder (immature),	4	11	64—74 68	- -	60—76 67	37—83 68	56—80 66	64—79 71
Dent corn fodder (in milk),	3	9	70	-	64	78	61	76
Dent corn fodder (glazing),	5	9	67	-	51	78	54	75
Dent corn fodder (mature),	2	4	65	-	55	73	51	72
Average (glazing and mature),	7	13	66	-	52	76	53	74
Dent corn fodder (ears glazing, Burrill and Whitman, coarse),	1	2	51—54 52	- -	46—47 46	74—82 78	20—28 24	57—61 59
Sweet corn fodder (milk),	1	2	77—78 77	- -	74—76 75	73—74 74	77—78 77	80—81 81
Sweet corn fodder (ears roasting stage), (Storrs),	3	6	- -	67—79 72	54—72 60	76—82 79	52—69 62	73—82 77
Early amber sorghum (just after blossom)	1	2	60.9—61.7 61	- -	41.7—45.3 42	67 -	37.7—42.5 40	70.4—70.8 71
Sorghum in blossom (variety not stated),	1	2	73.1—73.3 73	- -	74—75 75	81.3—81.6 81	51.1—55.7 53	78.2—78 78
Average both samples,	2	4	67	-	59	74	46	74
Green grass (young),	1	1	69	-	74	55	65	72
Same (dry),	1	1	71	-	77	60	71	73
Pasture grass,	1	2	71.9—75.6 74	- -	74.6—76.5 76	74—74.9 74	74—76.5 75	73.8—77.1 75
Average of three samples,	-	-	71	-	76	63	70	73
Rowen grass (mostly Timothy two-thirds grown),	1	2	- -	65—67 66	60—68 64	51—55 52	72—72 72	67—68 68
Barley fodder (bloom),	2	4	- -	62—71 67	49—66 61	56—63 60	69—73 72	69—76 71

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Green Fodders — Concluded.								
Oat fodder (bloom?),	1	2	- -	63—65 64	58—63 60	68—71 70	75—76 75	63—63 63
Rye fodder (formation of head),	1	2	73—74 74	- -	80—80 80	74—74 74	79—80 79	70—71 71
Hungarian grass (early to late bloom),	3	8	61—67 63	61—74 68	65—76 70	48—85 62	59—72 63	64—71 67
Peas and barley (full bloom),	1	2	- -	55—65 60	38—49 43	54—65 60	73—81 77	56—67 61
Peas and oats (bloom?),	1	2	- -	67—69 68	54—61 57	73—74 74	81—82 81	66—67 66
Clover fodder (late blossom),	1	2	65—67 66	- -	52—53 53	63—66 65	66—68 67	76—79 78
Clover rowen (mostly clover late bloom),	1	2	- -	60—62 61	51—54 52	60—61 61	61—62 62	64—68 65
Scarlet clover (late bloom),	1	3	- -	68—70 69	54—58 56	63—69 66	77—77 77	74—75 74
Average three samples,	3	7	-	-	54	64	70	72
Soy-bean fodder (before bloom, August),	1	2	- -	64—67 66	45—55 50	50—58 54	77—80 79	71—73 72
Soy-bean fodder (seed half grown),	1	2	- -	61—63 62	38—43 41	49—59 54	68—71 69	72—75 73
Cow-pea fodder (ready for soiling),	1	2	- -	76—76 76	57—58 57	56—62 59	73—75 74	84—84 84
Canada peas (just before bloom),	1	2	- -	71—72 71	62—62 62	50—55 52	81—83 82	71—71 71

Corn Silage.								
Dent silage (immature),	5	13	60—68 64	- -	71—78 70	64—85 71	42—65 54	60—70 66
Dent silage (milk to mature),	6	17	60 - 74 64	- -	45—80 62	78—90 85	45—63 52	63—73 69
Dent silage (stage uncertain, North Carolina),	1	4	53—67 60	- -	43—64 56	55—79 70	19—34 24	61—76 68
Flint silage (ears glazing),	4	11	68—78 75	66—80 77	75—79 77	- 82	48—73 65	71—83 79
Fine crushed silage (steers),	1	2	60.4—68 64	- -	72—78 75	75—77 76	32—44 38	60—70 65
Fine crushed silage (sheep),	1	2	51.5—56 54	- -	59.5—67.7 64	67.5—69 68	21—22 21.5	52.6—57.3 55
Corn silage (raw, ears mature),	1	1	-	-	59	86	45	71
Same (cooked),	1	1	-	-	70	87	39	75
Sweet corn ensilage (occasional ears mature),	1	2	66.6—69.6 68	68.5—71.7 70	68.4—73.7 71	82.3—84.6 83	52.7—55.2 54	70.7—73 72
Soy-bean ensilage (goats),	1	2	52—66 59	- -	47—62 55	66—77 72	71—80 76	46—58 52
Soy-bean ensilage (steers),*	1	2	50—50 50	- -	42—44 43	47—52 49	54—56 55	61—61 61
Cow-pea ensilage (steers),	1	4	59—60 60	- -	50—54 52	62—64 63	57—58 57	72—73 72
Barn-yard millet and soy-bean ensilage (sheep),†	1	4	54—65 59	- -	61—73 69	69—75 72	55—62 57	54—63 59
Corn and soy-bean ensilage (sheep),†	1	3	66—72 69	- -	59—73 65	80—84 82	63—67 65	73—78 75

* Must have been very mature as results are exceptionally low. See green soy bean.

† Millet was *P. crus-galli* (Japan). Corn was Pride of the North (medium dent). Soy bean was medium green.

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Roots, Tubers, etc.								
Potatoes,	1	3	73.3—80.1 77	74.6—81.2 78	- -	13 -	43.4—45.4 44	87.3—93.4 91
Sugar beets,	1	2	94.2—94.8 95	97.6—99.9 99	88.5—113 100	46.4—53.5 50	90—92.6 91	99.8—100 100
Mangolds,	1	2	77.1—80 79	82.7—87 85	26.8—58.8 43	- -	69.7—79.8 75	90.8—91.9 91
English flat turnips,	1	2	90.7—94.9 93	93.2—99 96	89.2—117 100	82.5—92.5 98	84.5—95 90	96—97 97
Ruta bagas,	1	2	84.4—90 87	89.2—93 91	61—87.5 74	76.8—91.6 84.2	74.7—85.9 80.3	94.4—95.1 95
Grains and Seeds.								
Corn meal (maize),	2	5	83—98 88	- -	- -	80—98 92	40—77 60	85—100 93
Corn and cob meal,	1	3	74—83 79	- -	2—86 45	82—85 84	43—65 52	86—91 88
Pea meal,	1	2	85—88 87	86—89 88	25—26 26	52—57 55	80—86 83	93—94 94
Raw cotton seed,	1	2	63—69 66	- -	65—86 76	- 87	66—70 68	49—50 50
Roasted cotton seed,	1	2	53—58 56	- -	62—69 66	68—75 72	44—50 47	50—53 51
Soy-bean meal,	2	10	75—82 79*	- 78	- -	81—90 85	- 87	- 73
Cotton seed meal,	2	6	67—82 76	- -	82 -	87—100 93	83—96 88	44—75 64

By-products.								
Cleveland linseed meal,	1	3	73—83 80	- -	49—100 74	90—98 93	86—88 85	82—87 84
Old-process linseed meal (National Linseed Oil Company),	1	3	75—82 79	- -	38—71 57	85—92 89	86—93 89	76—79 78
Gluten meal,	1	2	85—90 87	86—92 89	- 33	86—90 88	83—90 87	88—94 91
Chicago gluten meal,	1	2	87—89 88	- -	- -	92—94 93	87—91 89	93—94 93
King gluten meal,	1	2	79—82 81	- -	- -	91—97 94	- 91	78—81 79
Pope cream gluten meal,	1	2	92—95 93	- -	- -	96—99 98	88—84 84	85—91 88
Average all gluten meals,	4	8	87	-	-	93	88	88
Buffalo gluten feed (one lot),	1	2	76—80 78	- -	40—46 43	81—82 81	84—86 85	78—84 81
Buffalo gluten feed (another lot),	1	2	87—88 87	- -	84—94 89	92—95 93	87—87 87	87—87 87
Peoria gluten feed,	1	2	84—87 86	- -	59—97 78	76—82 79	81—85 83	90—90 90
Pope gluten feed,	1	2	86—87 87	- -	76—78 77	79—82 81	85—88 86	90—90 90
Average all gluten feeds,	4	8	84	-	72	83	85	87
Chicago maize feed,	1	2	83—85 84	- -	68—76 72	90—90 90	83—84 84	84—87 85
Atlas gluten meal (feed),	1	2	80—80 80	- -	?- ?-	90—92 91	73—73 73	84—85 84
Winter wheat bran,	1	3	57—66 62	- -	- 27	51—80 64	75—79 77	62—76 65

* For two sheep only.

Table of the Digestibility of American Feed Stuffs — Concluded.

KIND OF FODDER.	Number of Different Samples	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
By products — Concluded.								
Spring wheat bran,	1	2	62—63 63	- -	22—25 24	76—76 76	78—82 80	70—71 70
Average all wheat bran,	5	11	61	63	22	68	79	69
Wheat middlings,*	1	2	72.6—72.2 75	75.1—79.3 77	- -	84.1—86.1 85	78.4—79.4 79	80.7—84.5 83
Wheat middlings,*	1	2	79.48—85.63 83	- -	32.57—40.06 36	81.71—87.98 85	81.83—87.75 85	84.43—91.08 88
Rice meal,	1	2	71—76 74	- -	? ?	91—92 91	- 62	89—95 92
Rye meal,	1	2	85—90 87	- -	- -	63—65 64	83—85 84	89—94 92
Peanut feed,	1	2	32—32 32	- -	10—13 12	89—90 90	70—71 71	41—58 49
Malt sprouts,	1	1	67	68	34	100	80	69
Dried brewers' grains,	1	2	62—62 62	- -	50—55 53	89—93 91	78—81 79	59—59 59
Corn cobs,	1	2	59—60 59	- -	65—66 65	44—56 50	13—22 17	60—60 60

II. Experiments with Swine.

Maize kernels (whole),	1	1	83	83	38	46	69	89
Maize meal,	2	2	89.5–89.7 90	91.3–92.1 92	29.4–48.7 39	77.6–81.7 80	86.1–89.9 88	93.9–94.2 94
Maize meal (with cobs),	1	1	76	77	29	82	76	84
Pea meal,	1	1	90	92	78	50	89	95
Barley meal,	1	1	80	80	49	57	81	87
Wheat (whole),	1	?	72	-	30	60	70	74
Wheat (cracked),	1	?	82	-	60	70	80	83
Wheat shorts,	1	2	74–79 77	- -	25–48 37	- -	71–75 73	85.5–88 87
Wheat bran,	1	2	53.7–68.6 61	- -	29.6–39.1 34	65.4–78.1 72	74.4–75.8 75	56–75 66
Potatoes,	1	4	97	-	-	-	84	98

* Probably different products.

LITERATURE.

The following publications have been consulted in compiling the tables of the digestibility of American feed stuffs: —

Reports of Storrs (Connecticut) Experiment Station, 1894, 1895.

Reports of the Maine State Experiment Station for 1886, 1887, 1888, 1889, 1890, 1891, 1893, 1894.

Reports of the New York Experiment Station, 1884, 1888, 1889.

Reports of the Pennsylvania Experiment Station, 1887, 1888, 1889, 1890, 1891, 1892, 1893.

Bulletins Nos. 80 *c*, 81, 87 *d*, 97 and 118 of the North Carolina Experiment Station.

Bulletin No. 16, Utah Experiment Station.

Bulletin No. 3 of the Wisconsin Experiment Station for 1884, and Sixth Annual Report, 1889.

Bulletin No. 8 of the Colorado Experiment Station.

Bulletins Nos. 26 and 36 of the Minnesota Experiment Station.

Bulletin No. 6 of the Oregon Experiment Station.

Bulletins Nos. 13, 15 and 19 of the Texas Experiment Station.

Bulletins Nos. 20 and 41 of the Maryland Experiment Station.

Eleventh and Twelfth Annual Reports (1893 and 1894) of the Massachusetts State Experiment Station.

Report of Hatch Experiment Station, 1895, 1896.

Bulletin No. 43 of the Illinois Experiment Station.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN; Assistants: H. D. HASKINS, R. H. SMITH

PART I. FIELD EXPERIMENTS.

1. Experiments to study the effect of raising leguminous crops in rotation with grain crops on the nitrogen sources of the soil.
2. "Nitragin," a germ fertilizer for the cultivation of leguminous crops.
3. Observations with leguminous crops at Amherst.
4. Mixed annual forage crops *v.* clovers.
5. Experiments to study the economy of using natural phosphates in place of acid phosphates (superphosphates).
6. Experiments to ascertain the influence of different mixtures of chemical fertilizers on the character and yield of garden crops.

PART II. WORK IN THE CHEMICAL LABORATORY.

1. Report on inspection of commercial fertilizers.
2. New laws for the regulation of trade in commercial fertilizers.
3. Report on general work in the laboratory.
4. Compilation of analyses of manurial substances, fruits, garden crops and insecticides.

PART I.

REPORT ON FIELD EXPERIMENTS.

CHARLES A. GOESSMANN.

1. FIELD EXPERIMENTS CARRIED ON FOR THE PURPOSE OF STUDYING THE EFFECT OF A LIBERAL INTRODUCTION OF CLOVER-LIKE PLANTS — LEGUMINOUS CROPS — INTO FARM PRACTICE, AS A MEANS OF INCREASING THE RESOURCES OF AVAILABLE NITROGEN PLANT FOOD IN THE SOIL UNDER CULTIVATION FROM THE ELEMENTARY NITROGEN OF THE AIR. (*Field A.*)

The observation of the fact that the different varieties of clover and of clover-like plants in general, as peas, beans, vetches, lupines, etc., are in an exceptional degree qualified, under favorable conditions, to convert, by the aid of certain micro-organisms of the soil, the elementary nitrogen of the air into plant food, imparts to that class of farm crops a special interest from an economical stand-point. This circumstance is in a controlling degree due to the following two causes: —

First. — The nitrogen-containing soil constituents of plant food are, as a rule, in a high degree liable to suffer serious changes in regard to their character and fitness as well as in reference to their quantity.

Second. — Available nitrogen-furnishing manurial substances are the most costly articles of plant food in our markets.

Field experiments which propose to show, by their results, to what extent the cultivation of clover-like plants can be relied on as a practical and economical means for securing efficiently nitrogen plant food for the crops to be raised have

deservedly of late engaged the most careful attention of agricultural investigators.

The systematic treatment of the field here under consideration (Field A), as far as suitable modes of cultivation and of manuring are concerned, was introduced during the season of 1883 to 1884.

The subdivision of the entire area into eleven plats "one-tenth of an acre each," of a uniform size and shape, 132 feet long and 33 feet wide, with an unoccupied and unmanured space of 5 feet in width between adjoining plats, has been retained unaltered since 1884.

A detailed statement of the temporary aim and general management of the experiments, as well as of the results obtained in that connection from year to year, forms a prominent part of my contemporary printed annual reports, to which I have to refer for further details, 1884–96.

Our observations upon Field A are divided into three periods: —

(*a*) Study of the existing soil resources of plant food, 1884 to 1889.

(*b*) Study of the effect of excluding nitrogen plant food from outside sources and of adding nitrogen plant food in various available forms, 1889 to 1892.

(*c*) Studying the effect of the cultivation of leguminous crops on the resources of available nitrogen plant food in the soil under treatment, 1892 to 1897.

The first four years of the stated period 1884 to 1889 were principally devoted to an investigation into the general character and condition of the soil under cultivation as far as its natural and inherent resources of available phosphoric acid, nitrogen and potash were concerned.

The soil proved to be in particular deficient in potash. Different varieties of corn (maize) were raised in succession to assist in the investigation.

Since 1889 the main object of observation upon the same field has been to study the influence of an entire exclusion of any additional nitrogen-containing manurial substance from the soil under cultivation, as well as of a definite additional supply of nitrogen in different forms of combination on the character and yield of the crop selected for the trial.

Several plats (4, 7 and 9) which for five preceding years (1884 to 1889) had not received any nitrogen compound for manurial purposes, were retained in that state, to study the effect of an entire exclusion of nitrogen-containing manurial substances on the crop under cultivation; while the remaining ones received, as before, a definite amount of nitrogen in the same form in which they had received it in preceding years, namely, either as sodium nitrate (1, 2), as ammonium sulphate (5, 6, 8), as organic nitrogenous matter in form of dried blood (3, 10), or of barn-yard manure (0).

A corresponding amount of available nitrogen was applied in all these cases.

1889–94.

Plats.	Annual Supply of Manurial Substances per Plat (1-10 of one Acre).
Plat 0,	800 lbs. of barn-yard manure, 32 lbs. of potash-magnesia sulphate and 18 lbs. of dissolved bone-black.
Plat 1, .	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 2, .	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 3, .	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 4, .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 5, .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 6, .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 7, .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 8, .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 9, .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 10, .	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

Amount of Fertilizing Ingredients used annually per Acre.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen, ...	45 pounds.
	Phosphoric acid, . . .	80 pounds.
	Potassium oxide, . . .	125 pounds.
Plats 4, 7, 9, . . .	Nitrogen, ...	none.
	Phosphoric acid, . . .	80 pounds
	Potassium oxide, . . .	125 pounds.

The mechanical preparation of the soil, the incorporation of the manurial substances, the seeding, cultivating and harvesting, were carried on year after year in a like manner, and as far as practicable on the same day in case of every plat during the same year.

Kind of Crops raised.

Corn (maize),	in 1889.
Oats,	in 1890.
Rye,	in 1891.
Soy bean,	in 1892.

The annual yield of the various crops upon the different plats showed, as a rule, that those plats (4, 7, 9) which had not received in any form nitrogen for manurial purposes yielded much smaller crops than those that annually received in some form or other an addition of a corresponding amount of available nitrogen.

The total yield of crops on the plats receiving no nitrogen supply was, during the succeeding years, as follows: —

With corn in 1889, one-fifth less.

With oats in 1890, one-fifth to one-sixth less.

With rye in 1891, one-fifth to one-sixth less.

With soy bean in 1892, one-third to one-fourth less.

The results of four years (1889 to 1892) of observations were expressed in the following conclusions: —

The experiments carried on upon Field A during the years 1889, 1890, 1891 and 1892 show conclusively the importance of a liberal supply to the soil of an available form of nitrogen to secure a successful and remunerative cultivation of farm crops under otherwise corresponding favorable conditions. For even a leguminous crop, the soy bean, when for the first time raised upon Field A, did not furnish an exception to our observation (1892). (For details, see report for 1892.)

1893–97. — Subsequent to the year 1892, when for the first time in the more recent history of the field under discussion an *annual leguminous crop*, a late-maturing variety of soy bean, had been raised upon it, it seemed of interest to ascertain whether the raising of *the soy bean* upon Field A had increased the amount of available nitrogen stored up in

the soil to such an extent as to affect the yield of succeeding crops upon those plats (4, 7, 9) which, as a rule, had not received at any time for eight successive years an addition of available nitrogen from any other manurial source but the atmospheric air and the roots left in the soil after harvesting the crops raised.

A grain crop (oats) was selected as the crop suitable to serve for that purpose. The general management of the experiment, as far as the preparation of the soil, manuring and seeding-down are concerned, was the same as in previous years (see tenth annual report).

An examination of the yield of the crop in 1893, secured upon the different plats, showed that the total crop per acre on those plats to which no nitrogen was applied (4, 7, 9) averaged 800 pounds less than in case of the plats which received their regular supply of nitrogen in some form or other. The average yield of oats upon the plats (4, 7, 9) which had received no nitrogen supply from any outside source was *from one-seventh to one-eighth less in weight* than the average yield of the remaining plats, which received annually additional nitrogen supply.

From these results it appeared that the introduction of an annual leguminous crop into our rotation had somewhat reduced the difference in yield between the plats receiving no nitrogen and those receiving it, yet had not entirely obliterated it. It was decided to continue the observation by repeating the raising of soy beans in 1894, oats in 1895 and soy beans in 1896.

1894. — To secure, if possible, more decisive results regarding the presence and absence of available nitrogen, it was decided to use twice the amount of phosphoric acid and potassium oxide, as compared with the preceding years.

Amount of Fertilizing Ingredients applied per Acre during 1894.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.

An early-maturing variety of soy bean was selected for the experiments. The fertilizer mixtures were applied as in previous years, broadcast, in the middle of April. Owing to the protracted drought of July and August the crop did not get that fulness of growth which might have been obtained under more favorable conditions. The crop was cut August 28.

The difference in the average yield of crop between the plats (4, 7, 9) which thus far had received no available nitrogen from outside manurial sources, as compared with that from those which had received it in some form or other, was more marked than in previous years. It amounted to one-third in favor of the latter.

1895. — In 1895 oats were again selected, as stated above, to succeed soy bean, for the reason of permitting a direct comparison of the results of 1892 (soy bean) and 1893 (oats) with those of 1894 (soy bean) and 1895 (oats).

The ploughing, manuring, seeding down, etc., was carried out in the same manner as during the preceding season (1894).

The average yield of the plats with and without nitrogen supply from outside sources showed that no material change in their relative degree of productiveness had taken place.

1896. — It was decided to substitute in our experiment a perennial leguminous plant, medium red clover, for the annual leguminous plant, the soy bean, to ascertain whether more satisfactory results will be secured from that change.

As a few years' observation are required to obtain a satisfactory basis for reliable conclusions, reports are deferred.

2. Experiments with "Nitragin," a Germ Fertilizer for the Cultivation of Clover and Clover-like Plants — Leguminous Crops.

The history of progress in agriculture shows that a more general and liberal introduction of clover and clover-like plants, as beans, peas, vetches, etc., as forage crops, into a general system of farm management has everywhere increased the chances of a more remunerative farming. The valuable investigations of Laws and Gilbert have furnished striking

proofs of the special claims of these crops as nitrogen gatherers when compared in that direction with grain crops.

The subsequent important discovery of the real cause of the exceptional behavior of these crops by Hellriegel and others has given not only a satisfactory explanation of previous observations in practical agriculture but has also imparted, for economical reasons, an increased interest in the study of successful methods of raising clovers, etc., without the aid of a liberal supply of nitrogen-containing manurial substances.

Hellriegel and his co-laborers established by careful observation the fact that leguminous plants, like clovers, beans, vetches, lupines, etc., with the assistance of certain micro-organisms (root bacterium) found in the soil, can utilize the elementary nitrogen of the air for the formation of nitrogen plant food fit for the support of their growth.

These micro-organisms fasten themselves upon the roots of the clover, etc., penetrate the epidermis and form in the course of their growth swellings, nodules or tubercles, of varying size and shape. Their presence and growth in the tissue of the roots of this stated class of plants is considered an essential condition for the conversion of the elementary nitrogen of the air into suitable nitrogen plant food. The recognition of the circumstance that their presence or absence in the soil controls the results in a material degree, even under otherwise favorable conditions, has turned the attention of progressive agriculturists towards the study of the circumstances which secure success.

Quite prominent among the more recent results of investigation in this direction are the observations that a variety of root bacterium exists; that some infest the roots of one kind of leguminous plant while others thrive upon other kinds: that is to say, some leguminous crops may fail to give satisfactory returns where others prosper on account of the presence or absence of the right variety of root bacterium, or of suitable condition of the soil for their vigorous development.

These results caused the introduction of various modes of infecting the soil, wherever found necessary, with the desired kind of bacterium germ, before seeding down the new crop. A very common method consisted in scattering a

certain amount of soil, taken from a field where the crop to be raised has been successfully grown, over the surface of the new land before ploughing it. This method has been successfully practised by us on various occasions. Another is to abstract with water some of the soil, which from previous observation is known to contain the desired root bacterium germs, and sprinkle the watery extract over the soil before ploughing.

One of the latest developments in this direction is the appearance in the general market of patented germ fertilizer for leguminous crops. Considering the whole subject from a practical stand-point of sufficient interest, I insert below a copy of a circular received at this office. The connection of two German investigators of excellent reputation with the enterprise invites attention.

Three different kinds of germ fertilizers, for medium red clover, for crimson clover and for sweet or Bokhara clover, have been imported during the past season and are on trial upon the grounds of the station.

Nitragin.

Germ Fertilizers for Leguminous Crops.

(Prepared according to Drs. Nobbe and Hiltner.)

The principal food materials abstracted from the soil by plants, and which therefore require to be replaced in the form of manures, are potash, phosphoric acid, lime and nitrogen.

Respecting the last it has been known that leguminous crops, such as clover, vetches, peas, beans, lupines, etc , do not usually require to be manured with nitrogen (in form of nitre or ammoniacal compounds), and yet under favorable conditions yield rich harvests, whilst the soil is even enriched with nitrogen.

The reason of this peculiar behavior for many years remained unexplained, but the onward march of modern science has now demonstrated the ability of leguminous plants to abstract nitrogen from the air, only, however, by the aid of a specific kind of micro-organism, a bacterium that resides in the characteristic nodules on the roots. If these bacteria are not at the disposal of the plant then it looses its ability to utilize the atmospheric nitrogen, and hence it is found that not every leguminous plant is able to flourish luxuriantly without nitrogenous manure; many remain small and stunted under conditions otherwise favorable, and evidently suffer from the lack of nitrogen.

It is therefore a matter of extreme importance to the farmer to make certain that each field of legumes is supplied with the necessary quantum of bacteria; only then can he expect to obtain full crops from poor sandy soils without nitrogen manures (i. e., without saltpetre, ammonia, etc.), and only then will he reap the advantage of a soil enormously enriched with nitrogen.

The wide bearing of this newly discovered principle has already been taken into practical consideration, and fields are now inoculated, that is to say, strewn with earth in which legumes have already flourished. This method, however, apart from its great cost and the loss of time and labor entailed, also involves the danger of disseminating injurious as well as useful bacteria.

This disadvantage is, however, now completely overcome by the pure patent germ fertilizer Nitragin, which consists of a pure cultivation of the specific bacteria of legume nodules in a suitable medium.

The inoculation of the seed or of the soil with the germ fertilizer, according to the directions given below, possesses the following advantages: —

1. Every single seed is surrounded with bacteria which, after germination, penetrate the root hairs and commence their role as collectors of nitrogen, so that a good crop is secured in the poorest soil without nitrogenous manures.

2. Through the storage of nitrogen by the bacteria, the soil itself becomes richer in nitrogen in an assimilable state, to the advantage of the other crops grown in rotation.

3. The disadvantages of the mode of inoculation previously adopted are avoided.

4. Manuring with nitrogen in the form of saltpetre, ammonium salts, etc., is absolutely unnecessary.

Directions for Use.

Every bottle contains sufficient for inoculation of 2½ roods.

If the contents of the bottle have already become liquid, they are used as described below for the direct inoculation of the seed. If solid, the contents can be easily liquefied by warming the bottle gently for a few minutes, for instance, in the trousers' pocket, in tepid water or in a warm room. *Exposure to temperature above the heat of the body, which is amply sufficient to melt, or to direct sunlight must under all circumstances be strictly avoided.*

The liquid contents are poured into a vessel containing one to three pints of clean water (carefully washing out the whole contents of the bottle with a little water), and then shaken or stirred

until the fertilizer is equally distributed throughout the vessel and the bacteria are well mixed in the water.

The inoculated water thus prepared is poured over the seed and worked with the hands (or the shovel) until every seed has been moistened. If the quantity of water is insufficient more must be added, but usually for small seed a pint and a half will suffice and for large seeds two to three quarts. The moistened seed is then reduced to a condition suitable for sowing by mixing with some dry sand or fine earth and if necessary allowing it to stand, turning it over from time to time; too great dryness is deleterious. The sowing and turning in is carried out in the manner usually practised. If possible, however, avoid sowing in glaring sunlight.

Instead of inoculating the seed, the same and, in some cases, better results are obtained by inoculating the soil by means of inoculated earth. For this purpose for every $2\frac{1}{2}$ roods one-half a hundred weight of earth is inoculated in the above-described manner, using a proportionately larger quantity of water; the inoculated earth is then dried in the air or mixed with dried earth, scattered equally over the field, and worked in three or four inches deep.

For larger surfaces than $2\frac{1}{2}$ roods a corresponding number of bottles must be used (8 bottles to 5 acres).

As the bacteria are absolutely innocuous, there is no fear of danger from the bottles being left about or employed for other purposes.

Attention is specially directed to the fact that the "germ fertilizers" should only be used for the species of Leguminosæ marked on the label of the bottle. For greater distinction the bottles bear differently colored labels.

Manufactured by the Farbwerke vorm. Meister Lucius & Bruning, Hoechst on Main, Germany.

Specification of the Various Kinds of "Nitragin" (registered) Germ Fertilizers for Leguminous Crops.

Common pea (*Pisum sativum*), red label.
Sand pea (*Pisum arvense*), red label.
Common vetch (*Vicia sativa*), blue label.
Hairy vetch (*Vicia villosa*), blue label.
Common field bean or horse bean (*Vicia faba*), blue label.
White lupine (*Lupinus albus*), green label.
Yellow lupine (*Lupinus lutens*), green label.
Blue lupine (*Lupinus angustifolus*), green label.
Clover, red (*Trifolium pratense*), label gold on green.
White clover or Dutch clover (*Trifolium repens*), label gold on green.

Alsike clover (*Trifolium hybridum*), label gold on green.
Carnation clover or trifolium (*Trifolium incarnatum*), label gold on green.
Bokhara clover (*Melilotus alba*), label gold on green
Black medick (*Medicago lupulina*), label gold on white.
Lucerne (alfalfa) (*Medicago sativa*), label gold on white.
Kidney vetch (*Anthyllis vulneraria*), label gold on white.
Sainfoin (*Onobrychis sativa*), gold label on violet.
Serradella (*Ornithopus sativus*), label gold on pink.
Wild everlasting pea (*Lathyrus sylvestris*), label gold on blue.

When giving your esteemed orders for Nitragin we shall thank you to state always, for what kind of leguminous crops you wish to receive the germ fertilizers.

Yours respectfully,
FARBWERKE VORM. MEISTER LUCIUS & BRUNING.

3. OBSERVATIONS WITH LEGUMINOUS CROPS AT AMHERST.

The cultivation of leguminous crops has for years received special attention at our hands. The majority of reputed leguminous forage crops congenial to our climate have been raised repeatedly and on a sufficiently large scale in most instances to form a fair opinion regarding their merits as forage crops in our section of the country.

The following statement contains the kinds of leguminous crops experimented with at Amherst: —

Medium red clover (*Trifolium medium*).
Alsike clover (*Trifolium hybridum*).
Crimson clover (*Trifolium incarnatum*).
Japanese clover (*Lespedeza striata*).
Bokhara clover (sweet clover) (*Melilotus alba*).
Serradella (*Ornithopus sativus*).
Sainfoin (*Onobrychis sativa*).
Alfalfa (*Medicago sativa*.)
Scotch tares.
Lentil (*Ervum lens*).
Summer vetch (*Vicia sativa*).
Kidney vetch (*Anthyllis vulneraria*).
Horse bean (*Vicia faba*).
Early-maturing soy bean (*Soja hispida*).
Late-maturing soy bean (*Soja hispida*).
Peas (*Pisum sativum*).
Cow pea (*Dolichos sinensis*).
Flat pea (*Lathyrus sylvestris*).
White lupine (*Lupinus albus*).
Yellow lupine (*Lupinus luteus*).
Blue lupine (*Lupinus perennis*).

For details I have to refer to previous annual reports.

The following local observations are worth mentioning again on this occasion: —

(*a*) Alfalfa (*Medicago sativa*) and crimson clover (*Trifolium incarnatum*), in repeated trials, suffered seriously from winter-killing. This result has to be ascribed more to late frosts early in spring, when the ground is filled with water, than to the severity of mid-winter.

(*b*) Mixed crops of peas, vetch and horse bean, and vetch and oats or barley have given, as a rule, very satisfactory returns as far as quality and quantity are concerned.

(*c*) Soy beans, early and late varieties, have yielded, as a rule, during average seasons large crops; yet they have failed to enrich the soil they were raised upon sufficiently in available nitrogen plant food to secure under otherwise corresponding conditions, as far as the supply of available potash and phosphoric acid is concerned, as high a yield of a succeeding crop of rye, oats, barley and even soy bean, as where from forty to fifty pounds per acre of an available form of nitrogen were added. The liberal addition of nitrates to the soil interfered with a liberal development of root tubercles, in case of soy bean, in a well-infected soil.

Similar results are reported by other investigators in regard to lupines followed by oats or potatoes; an addition of nitrates in connection with a potash and phosphoric acid containing fertilizer increased the yield. The infection of the soil by lupine bacterium did not benefit the growth of other leguminous crops.

The belief that each variety of leguminous crop is associated with a root bacterium of its own finds support in the circumstance that the root tubercles of different varieties of these crops quite frequently vary, not only in size and shape but in their mode of distribution over the main roots or rootlets. Illustrations of this feature have been furnished by the writer in form of photographs from nature in case of soy bean, horse bean, lupines, etc., (see State station report for 1894).

Much has been learned regarding the symbiotic or combined life of root bacteria and leguminous plants, yet much further investigation in the vegetation house and the field

is evidently needed *to secure to the full extent* and with certainty the economical advantages to be derived from the raising of crops which are capable of converting, without expense, the elementary nitrogen of the air into available nitrogen plant food.

Our attention, as will be seen from preceding statements, has been of late directed to the question *whether perennial leguminous crops, as our current varieties of clovers*, may prove more satisfactory as nitrogen gatherers for general farm purposes than annual leguminous crops, as soy bean, lupines, etc.

4. Mixed Annual Forage Crops v. Clovers (*Field B*).

The importance of a more liberal and economical supply of nutritious forage crops for the support of farm live stock is quite generally recognized by all parties interested.

Mixed forage crops, consisting of early-maturing annual leguminous crops, clover-like plants and of either oats or barley, suggested themselves for trial; for they attain in our locality a high feeding value at a comparatively early period of the season, — towards the end of June when in bloom; they can serve with benefit in form of green fodder, hay or ensilage, as circumstances advise; they yield under fair conditions large quantities of fodder of a highly nutritious character, and permit a timely reseeding and maturing of a second crop upon the same lands.

The fields used for our earlier observations, in 1893–94, were located in different parts of the farm. They were, as a rule, in a fair state of cultivation, as far as the mechanical condition of the soil as well as its store of plant food was concerned. The soil consisted in the majority of cases of a somewhat gravelly loam (see reports for 1893–94).

The field used in the experiments, subsequently described somewhat in detail, consisted of a light loam and was divided into eleven plats of corresponding shape with four feet of unoccupied space between them. It was used for the cultivation of potatoes in preceding years. The plats had received on that occasion in all cases the same amount and form of nitrogen and phosphoric acid, in form of ground bones, while the potash supply consisted in alternating

order of plats either of muriate of potash or of high-grade sulphate of potash, containing the same amount of potassium oxide in every case (400 pounds of muriate of potash, 80 to 82 per cent., or of high-grade sulphate of potash, 95 per cent., and 600 pounds of fine-ground bones per acre). This system of manuring the plats has been followed ever since 1893. The same crops have been raised each season upon adjoining plats to notice the particular effect of both forms of potash on the crop raised (for details see previous reports).

Vetch and Oats and Vetch and Barley.

1894. — The same amount and kind of manure were applied for raising vetch and oats and vetch and barley. The field occupied by these crops was ploughed, manured, harrowed and seeded down, as far as practicable, at the same time. The seed was sown in all cases April 26. Four bushels of oats with 45 pounds of vetch were sown, as on previous occasions, while 3 bushels of barley were used with 45 pounds of vetch per acre in case of barley and vetch. Both crops came up May 4 and were of a uniformly healthy condition during their subsequent growth. The barley began to head out June 20; the vetch was at that time beginning to bloom. The crop was cut for hay June 23.

It needs no further statement to understand that the quality of the seeds and of the soil ought to be considered in deciding about weights of the former. Close cultivation is desirable in case of this class of forage crops, for it favors a succulent, tender structure and keeps weeds out.

Average Yield of Crops.

Yield of Barley and Vetch per Acre.

In case of muriate of potash and bone, . .	5,737 pounds of hay.
In case of sulphate of potash and bone, . .	5,077 pounds of hay.

The oats headed out June 25; the vetch was fairly in bloom at this time. The crop was cut for hay July 2.

Yield of Oats and Vetch per Acre.

In case of muriate of potash and bone, . .	8,051 pounds of hay.
In case of sulphate of potash and bone, . .	7,088 pounds of hay.

1895. — During that year the observations of the preceding year were repeated and in some directions enlarged; oats, vetch and horse bean, and oats and lentils were added to those of the preceding year. The same kind and quantity of manures were applied. The field was ploughed April 25 and the manure harrowed in May 3; the seed was sown broadcast May 9. All parts of the field were treated alike, and as far as practicable on the same day. The plats occupied by the crops were in all cases 33 feet wide, with 4 feet unoccupied space between them, and from 191 to 241 feet long. The yield of areas 175 feet long and 33 feet wide, running along by the side of each other, served as our basis for comparing results (5,775 square feet) (for details see report for 1895).

Yield of Vetch and Oats per Acre.

In case of muriate of potash and bone, ...	7,238 pounds.
In case of sulphate of potash and bone, ...	6,635 pounds

Yield of Vetch, Horse Bean and Oats per Acre.

In case of muriate of potash and bone, ...	7,398 pounds
In case of sulphate of potash and bone, ...	5,881 pounds.

Yield of Oats and Lentils per Acre.

The experiment was confined to a trial with sulphate of potash and bone as manure on account of want of a suitable field. The yield was 5,881 pounds of hay.

After the crops stated had been harvested, during the middle of July, in the form of hay, the field was ploughed and prepared for the cultivation of a variety of clovers, mammoth red clover, medium red clover, alsike or Swedish clover, crimson clover and sweet or Bokhara clover, to compare the crops resulting during two succeeding years with those obtained in case of mixed crops of vetch and oats, etc.

The subdivision of the field into eleven plats was the same as in the preceding year; each plat received the same kind and amount of fertilizer as before; the mechanical preparation of the soil was in all cases the same. The seeding down of the different plats took place on the same day, July 23, 1895.

Plats 11 and 12 were each seeded down with 3 pounds of sweet clover seed.

Plats 13 and 14 were each seeded down with 3 pounds of mammoth red clover seed.

Plats 15 and 16 were each seeded down with 3 pounds of medium red clover seed.

Plats 17 and 18 were each seeded down with 2½ pounds of alsike or Swedish clover seed.

Plats 19 and 20 were each seeded down with 4 pounds of crimson or scarlet clover.

Plats 11, 13, 15, 17 and 19 received their potash in form of muriate of potash (80 to 82 per cent.); plats 12, 14, 16, 18 and 20 in form of high-grade sulphate of potash (95 per cent.).

Subsequent History of Crops on Different Plats.

Plats 11 and 12. — The frost affected the crop somewhat by heaving of the soil; the growth was thin and of a light color except in some instances where a deep color and large growth was noticed. A subsequent examination showed in these cases an exceptional development of tubercles on the roots. The crop was harvested June 19.

Plat 11. — Crop weighed green 200 pounds.

Plat 12. — Crop weighed green 285 pounds.

On account of unsatisfactory condition of the plats both were ploughed July 15 and reseeded on July 30, 1896, with 10 pounds of sweet clover seed each, to notice whether a more liberal infection of the soil with suitable bacterium thus secured would result in better and larger returns. Nov. 1, 1896, the crop was looking well and was one foot in height. The dark spots of growth had spread greatly.

Plats 13 and 14. — The crops upon these plats looked well in the fall and during the succeeding spring. The crop was cut before it had reached full bloom, June 23, on account of its being badly lodged; they were harvested as hay June 29.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Yield of Rowen (Pounds).	Total Yield of Dry Matter (Pounds).
13, ...	615	295	756.65
14, ...	650	305	796.32

The sod looked well on both plats Nov. 1, 1896.

Plats 15 and 16. — The crop looked healthy in the fall and in the succeeding spring; the crop was cut when in full bloom, June 19, and harvested June 23. The rowen was cut July 28 and harvested July 30. A third crop was cut October 9 and harvested October 26.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Yield of Second Crop (Pounds).	Yield of Third Crop (Pounds).	Total Yield of Dry Matter (Pounds).
15, ...	455	276	120	686.62
16, ...	455	294	120	720.55

The sod looked to be in good condition on both plats Nov. 1, 1896.

Plats 17 and 18. — The crop looked well from the beginning and was in bloom June 7. The hay was cut and harvested June 19 and 23.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Yield of Rowen (Pounds).	Total Yield of Dry Matter (Pounds).
17, ...	620	325	733.21
18, ...	455	200	518.56

Nov. 1, 1896, the sod looked exhausted and was covered with weeds and sorrel.

Plats 19 and 20. — These plats looked well in early winter but almost every plant died out in early spring. The plats were reseeded during the month of April, 1896, with 5½ pounds of seed on each plat. The hay was cut when in bloom July 17 and harvested July 23. The crop was in poor condition when cut and never sprouted again.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Total Yield of Dry Matter (Pounds).
19,	575	422.91
20,	595	406.94

Summary of Yield of Crops in 1896 (Dry Matter).

[Pounds.]

PLATS.	Hay.	Rowen.	Total Yield of Dry Matter.
11,	–	–	–
12,	–	–	–
13,	511.62	245.03	756.65
14,	541.58	254.74	796.32
15,	373.46	313.16	686.62
16,	390.12	330.43	720.55
17,	458.49	274.72	733.21
18,	356.54	162.02	518.56
19,	422.91	–	422.91
20,	406.94	–	406.94

5. Field Experiments with Different Commercial Phosphates, to study the Economy of using the Cheaper Natural Phosphates or the More Costly Acidulated Phosphates. (*Field F.*)

The field selected for this purpose is 300 feet long and 137 feet wide, running on a level from east to west. Previous to 1887 it was used as a meadow, which was well worn out at that time, yielding but a scanty crop of English hay. During the autumn of 1887 the sod was turned under and left in that state over winter. It was decided to prepare the field for special experiments with phosphoric acid by systematic exhaustion of its inherent resources of plant food. For this reason no manurial matter of any description was applied during the years 1887, 1888 and 1889.

The soil, a fair sandy loam, was carefully prepared every year by ploughing during the fall and in the spring, to improve its mechanical condition; during the same period a crop was raised every year. These crops were selected, as far as practicable, with the view to exhaust the supply of phosphoric acid in particular. Corn, Hungarian grass and leguminous crops (cow pea, vetch and serradella) followed each other in the order stated.

In 1890 the field was subdivided into five plats, running from east to west, each 21 feet wide with a space of 8 feet between adjoining plats. The manurial material applied to each of these five plats contained, in every instance, the same form and the same quantity of potassium oxide and nitrogen, while the phosphoric acid was furnished in each case in the form of a different commercial phosphoric-acid-containing article, namely, phosphatic slag, Mona guano, Florida phosphate, South Carolina phosphate, floats and dissolved bone-black. The market cost of each of these articles in 1890 controlled the quantity applied, for each plat received the same money value of its particular kind of phosphate. The phosphatic slag, Mona guano, South Carolina phosphate, floats and Florida phosphate were applied at the rate of 850 pounds per acre, dissolved bone-black at the rate of 500 pounds per acre. Nitrate of soda was applied at the rate of 250 pounds per acre and potash-magnesia sulphate at the

rate of 390 pounds per acre. (For the analysis of phosphates and cost of each in 1890 see report for 1895.)

The following fertilizer mixtures have been applied annually, from 1890 to 1894, to all plats, with the exception of Plat 3, which received in 1890 ground apatite and in 1891 no phosphate whatever, on account of the failure of securing in time apatite suitable for the trial.

PLATS.	Annual Supply of Manurial Substances.	Pounds.
Plat 1 (south, 6,494 square feet),	Ground phosphatic slag,	127
	Nitrate of soda,	43
	Potash-magnesia sulphate,	58
Plat 2 (6,565 square feet),	Ground Mona guano,	128
	Nitrate of soda,	43½
	Potash-magnesia sulphate,	59
Plat 3 (6,636 square feet),	Ground Florida phosphate,	129
	Nitrate of soda,	44
	Potash-magnesia sulphate,	59
Plat 4 (6,707 square feet),	South Carolina phosphate,	131
	Nitrate of soda,	44½
	Potash-magnesia sulphate,	60
Plat 5 (6,778 square feet),	Dissolved bone-black,	78
	Nitrate of soda,	45
	Potash-magnesia sulphate,	61

Names of Crops raised from 1890 to 1894.

1890, potatoes (see eighth annual report of Massachusetts State station); 1891, winter wheat (see ninth annual report of Massachusetts State station); 1892, serradella (see tenth annual report of Massachusetts State station); 1893, Dent corn, Pride of the North (see eleventh annual report of Massachusetts State station).

Summary of Yield of Crops (Pounds).

PLATS.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.
Plat 1, phosphatic slag,	1,600	380	4,070	1,660
Plat 2, Mona guano,	1,415	340	3,410	1,381
Plat 3, Florida phosphate,	1,500	215	2,750	1,347
Plat 4, South Carolina floats,	1,830	380	3,110	1,469
Plat 5, dissolved bone-black,	2,120	405	2,920	1,322

Having for four years (1890–94) in succession pursued the above-stated system of manuring each plat with a differ-

ent kind of phosphate, yet of corresponding money value, it was decided to continue the experiments for the purpose of studying the *after-effect* of the different phosphates on the crops to be raised. To gain this end the phosphates were hereafter in all cases entirely excluded from the fertilizers applied; in addition to this change, the former amount of potash and nitrogen was increased one-half in quantity, to favor the highest effect of the stored-up phosphoric acid in the soil under treatment.

The fertilizers hereafter used had the following composition: —

Plat 1 (6,494 square feet), ...	64½ pounds of nitrate of soda. 87 pounds of potash-magnesia sulphate.
Plat 2 (6,565 square feet), ...	65¼ pounds of nitrate of soda. 88 pounds of potash-magnesia sulphate.
Plat 3 (6,636 square feet), ...	66 pounds of nitrate of soda. 89 pounds of potash-magnesia sulphate.
Plat 4 (6,707 square feet), ...	66¾ pounds of nitrate of soda. 90 pounds of potash-magnesia sulphate.
Plat 5 (6,778 square feet), ...	67½ pounds of nitrate of soda. 90¾ pounds of potash-magnesia sulphate.

The results of three years (1894 to 1896) are as follows: —

Barley.

Yield of Crop (1894).

Plats.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds)	Percentage of Grain.	Percentage of Straw.
Plat 1, ...	490	169	221	34.49	65.51
Plat 2, ...	405	148	251	34.07	65.93
Plat 3, ...	290	78	212	26.89	73.11
Plat 4, ...	460	144	216	31.30	68.70
Plat 5, ...	390	118	272	30.26	69.74

Rye.

Yield of Crop (1895).

Plats.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1, ...	695	195	500	28.06	71.94
Plat 2, ...	631	166	465	26.31	73.69
Plat 3, ...	383	143	240	37.34	62.66
Plat 4, ...	759	189	570	24.90	75.10
Plat 5, ...	625	185	440	29.60	70.40

Medium Green Soy Bean.

Yield of Crop (1896).

PLATS.	Whole Crop (Pounds).	Beans (Pounds).	Straw, etc. (Pounds).	Percentage of Beans.	Percentage of Straw, etc.
Plat 1, .	680	254	426	37.20	62.80
Plat 2, .	773	233	540	30.14	69.86
Plat 3, .	717	262	455	36.54	63.46
Plat 4, .	752	252	500	33.51	66.49
Plat 5, .	742	247	495	31.94	68.06

Summary of Yield of Crops (1890 to 1896).

[Pounds.]

PLATS.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.	1894. Barley.	1895. Rye.	1896. Soy Bean.
Plat 1, phosphatic slag,	1,600	380	4,070	1,660	490	695	254
Plat 2, Mona guano, .	1,415	340	3,410	1,381	405	630	233
Plat 3, Florida phosphate.	1,500	215	2,750	1,347	290	383	262
Plat 4, South Carolina phosphate (floats).	1,830	380	3,110	1,469	460	759	252
Plat 5, dissolved bone-black.	2,120	405	2,920	1,322	390	625	247

Conclusions.

From the previous statement of comparative yields for average successive years we find that the plat receiving dissolved bone-black leads in yield during the first two years while the third, fourth, fifth and sixth years the plats receiving phosphates insoluble in water are ahead, phosphatic slag being first, with South Carolina floats second.

The following statement regarding the phosphoric acid applied in the case of each plat, and also the amount removed from them by the crops raised, shows approximately how much the former is still stored up in the soil in each plat, not considering the original inherent amount in the soil at the beginning of the trial: —

Phosphoric Acid applied to and removed from Field (Pounds).

PLATS.	1890. Potatoes.		1891. Wheat.		1892. Serradella.		1893. Corn.		Total Amount added.	Total Amount removed.	Total Amount remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1, .	24.18	2.56	24.18	1.23	24.18	8.95	24.18	7.20	96.72	19.94	77.78
Plat 2, .	28.01	2.36	28.01	1.19	28.01	7.50	28.01	6.33	72.04	17.38	54.66
Plat 3, .	109.68	2.40	–	.69	28.01	6.05	28.01	5.95	165.70	15.09	150.61
Plat 4, .	36.12	2.93	36.12	1.31	36.12	6.84	36.12	6.68	144.48	18.12	126.36
Plat 5, .	12.34	3.39	12.34	1.22	12.34	6.42	12.34	6.05	49.36	17.08	32.28

Phosphoric Acid applied to and removed from Field (Pounds) — Concluded.

PLATS.	1894. Barley.		1895. Rye.		1896. Soy Bean.		Total Amount added.	Total Amount removed.	Total Amount remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1, ...	–	1.92	–	3.41	–	5.84	96.72	31.11	65.61
Plat 2, ...	–	1.64	–	3.04	–	5.75	72.04	27.81	44.23
Plat 3, ...	–	.76	–	2.06	–	6.07	165.70	23.98	141.72
Plat 4, ...	–	1.72	–	3.61	–	6.01	144.48	29.46	115.02
Plat 5, ...	–	1.49	–	3.11	–	5.89	49.36	27.57	21.79

The experiment needs continuation to secure more decisive results.

6. Field Experiments to ascertain the Influence of Different Mixtures of Commercial Fertilizers on the Yield and General Character of Several Prominent Garden Crops.

The area devoted to the above-stated experiment is 198 feet long and 183 feet wide; it is subdivided into six plats of uniform size (89½ by 62 feet, or about one-eighth of an acre each). The plats are separated from each other and from the adjoining cultivated fields by a space of 5 feet of unmanured and unseeded yet cultivated land.

They are arranged in two parallel rows, running from east to west. Plats Nos. 1, 2 and 3 are along the north side of the field, beginning with No. 1 at its west end, while plats Nos. 4, 5 and 6 are located along its south side, beginning with Plat 4 on the west end. The soil is several feet deep, and consists of a light, somewhat gravelly loam, and was in a fair state of productiveness when assigned for the experiment here under consideration. The entire field occupied by the experiment is nearly on a level. Potatoes and a variety of forage crops have been raised upon it in preceding years. The manure applied since 1885 has consisted exclusively of fine-ground bone and muriate of potash, annually, 600 pounds of the former and 200 pounds of the latter per acre.

The observation with raising garden crops by aid of the different mixtures of commercial manurial substances, here under special consideration, began upon plats Nos. 4, 5 and 6 during the spring of 1891, and upon plats Nos. 1, 2 and 3 during that of 1892.

The difference of the fertilizers applied consisted in the circumstance that the different forms of nitrogen and potash were used for their preparation. All plats received essentially the same quantity of nitrogen, potash and phosphoric acid, and every one of them received its phosphoric acid in the same form, namely, dissolved bone-black. Some plats received their nitrogen supply in form of organic animal matter, dried blood; others in form of sodium nitrate, Chili saltpetre; others in the form of ammonium sulphate. Some plats received their potash in the form of muriate of potash

(plats 1, 2, 3), and others (plats 4, 5, 6) in the form of the highest grade of potassium sulphate (95 per cent.). The subsequent tabular statement shows the quantities of manurial substances applied to the different plats: —

Plats.	Annual Supply of Manurial Substances.	Pounds.
Plat 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

This proportion corresponds per acre to: —

	Pounds.
Phosphoric acid (available),	50.4
Nitrogen,	60.0
Potassium oxide,	120.0

A computation of the results of a chemical analysis of twenty prominent garden crops shows the average relative proportion of the three above-stated ingredients of plant food: —

	Per Cent.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain on the above-stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weights and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limits pays, as a rule, better than a scanty one, especially in the case of those crops which reach in a short period the desired state of maturity.

The various mixtures of fertilizers used in the experiments under discussion provided by actual supply for one-half of the available nitrogen actually called for to meet the demand as above pointed out. A liberal cultivation of peas and beans cannot fail to benefit the nitrogen resources of the soil. The order of arrangement of the different crops within each plat was the same in all of them for the same year.

They occupied, however, a different position relative to each other in successive years, to introduce, as far as practicable, a system of rotation of crops. (For details see previous annual report.)

Statement of Crops raised since 1891.

1891 and 1892.	1893.	1894.	1895 and 1896.
Celery.	Onions.	Onions.	Onions.
Lettuce.	Lettuce.	Sweet corn.	Sweet corn.
Spinach.	Spinach.	–	–
Beets.	Beans.	Beans.	Beans.
Cabbage.	–	–	–
Tomatoes.	Tomatoes.	Tomatoes.	Tomatoes.
Potatoes.	Potatoes.	–	–

Season of 1896. — The field was ploughed April 20. The fertilizers were the same as in the preceding years; each of the six plats received the same amount and kind of fertilizer, which was harrowed in April 24.

The crops raised during the season of 1896 were : —

Onions (Danvers Globe).
Tomatoes (Dwarf Champion).
Beans (Dwarf Horticultural).
Sweet Corn (Early Crosby).

Onions.

The seed was sown April 28. Each plat contained fifteen rows 14 inches apart ; the weeds were kept down by frequent use of the hand cultivator ; the crop was weeded by hand twice ; the crop was rolled September 7. Those plats (4, 5, 6) which received their potash supply in form of high-grade sulphate of potash matured first, while those plats (1, 2, 3) receiving muriate of potash matured somewhat later. The crop upon Plat 1 was the latest to mature, while that upon Plat 2, receiving nitrate of soda, was the most advanced plat in the field. The onions were pulled September 7, topped October 5 and weighed October 9.

Yield of Onions (Pounds).

PLATS.	Large Onions.	Small Onions.	Scallions.	Total Yield.
Plat 1, . .	490	29	100	628
Plat 2, . .	697	24	30	751
Plat 3, . .	659	49	60	768
Plat 4, . .	489	26	55	570
Plat 5, . .	494	21	30	545
Plat 6, . .	595	54	50	699

Tomatoes.

It was deemed best in this experiment to procure an earlier maturing variety than the one used in the preceding year, to meet our market demands. The plants were started at the plant house of the horticultural department. The plants were set May 21 3 to 4 feet apart, two rows in each plat ; each plat contained 44 plants ; they were cultivated five times and hand-hoed three times.

Field C. Yield of Tomatoes (Pounds).

DATE OF PICKING.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.
July 18,	–	–	.40	–	–	.14
July 22,	.40	–	.12	–	–	.12
July 25,	1.10	.30	1.11	.30	.13	.12
July 28,	2.12	1.00	2.80	2.60	2.10	6.40
July 30,	3.20	2.10	2.80	1.14	4.00	3.40
August 1,	4.00	6.00	3.40	5.00	8.00	4.00
August 3,	8.40	6.80	8.80	7.00	5.80	7.00
August 5,	8.12	8.40	9.00	7.60	10.40	9.40
August 8,	10.12	15.00	15.00	13.80	17.00	18.00
August 10,	17.40	13.80	11.00	14.00	12.12	19.40
August 12,	7.40	8.80	5.00	12.00	13.40	9.40
August 15,	13.80	25.00	21.40	34.00	32.12	25.12
August 17,	17.00	44.80	21.12	45.00	49.40	36.12
August 19,	9.00	16.80	22.40	17.00	22.12	17.12
August 21,	6.12	14.80	18.40	7.80	15.40	8.40
August 24,	12.80	31.00	18.80	21.80	39.40	30.40
August 26,	13.12	33.80	17.00	20.00	35.80	26.80
August 29,	Not weighed.*	36.00	Not weighed.*	32.00	33.40	27.12
September 1,		50.80		49.12	68.40	53.00
September 4,		55.80		61.00	63.40	77.00
September 7,		48.80		44.00	54.00	63.00
September 11,		37.00		46.80	47.40	51.12
September 16,		34.00		55.00	35.00	42.00
September 21,		7.00		10.00	9.80	12.00
Green tomatoes,	28.00	10.80	40.00	24.00	9.00	14.00

* Records not complete.

Beans.

The beans were planted in rows 2½ feet apart, there being seven rows in each plat. The seed was planted May 19, the young plants appeared above ground June 1; they were cultivated five times and hand-hoed three times; the beans on all plats alike rusted badly. The beans were pulled and stacked in the field August 19.

Yield of Beans (Pounds).

PLATS.	Beans.	Pods and Vines.	Total Weight.
Plat 1,	31	30	61
Plat 2,	53	44	97
Plat 3,	52	44	96
Plat 4,	58	45	103
Plat 5,	67	51	118
Plat 6,	48	42	90

Sweet Corn.

Each plat contained five rows, the latter being 3 feet 3 inches apart: the hills were 20 inches apart, there being three plants left in each hill, making 1,060 hills per plat.

The crop appeared above ground June 1. It was subsequently cultivated five times and hand-hoed three times. In order to hasten maturity the stalks were topped September 9.

The corn was harvested and weighed October 9 with the following results: —

Sweet Corn (Early Crosby). Yield in Pounds per Plat.

PLATS.	Ears.	Stover.	Total Weight.
Plat 1,	190.0	250	445.0
Plat 2,	240.0	280	520.0
Plat 3,	195.0	335	530.0
Plat 4,	190.0	310	500.0
Plat 5,	182.5	290	472.5
Plat 6,	190.0	302	492.0

Conclusions drawn from Four Years of Observation.

1. Sulphate of potash in connection with nitrate of soda (Plat 5) has given in every case but one (onions) the best results.

2. Nitrate of soda as nitrogen source (plats 2 and 5) has yielded in almost every case, without reference to form of potash, the best results.

3. Sulphate of ammonia as a nitrogen source, in connection with muriate of potash as source of potash (Plat 1), has given as a rule the least satisfactory returns. This fact is evidently due to a change of chloride of potash and sulphate of ammonia into sulphate of potash and chloride of ammonium, the latter being an unfavorable form of nitrogen plant food.

4. The influence of the difference in the general character of the weather, whether normal or dry, during succeeding seasons on the yield of the crops has been greater than that of the different fertilizers used upon different plats during the same season.

Note. — The general management of the field work connected with the previously described continuation of my experiments was attended to by Mr. H. M. Thomson, Assistant Agriculturist of the Hatch Experiment Station, to whom I take pleasure in expressing my thanks for his cheerful assistance.

Part II.

REPORT ON THE WORK IN THE CHEMICAL LABORATORY.

Charles A. Goessmann.

1. On Official Inspection of Commercial Fertilizers and Agricultural Chemicals in 1896.

During the past year fifty-seven manufacturers and dealers in commercial fertilizers and agricultural chemicals have applied for and secured licenses for the sale of their goods in the State. Thirty-three of these parties have offices for general distribution within our State, nine in the State of New York, six in Connecticut, three in Vermont, three in Rhode Island, two in Pennsylvania and one in Illinois.

The number of distinct brands licensed, including agricultural chemicals, amounted to two hundred and sixty-five.

The sampling and collecting of the material for official analyses were in charge of Mr. H. D. Haskins, a graduate of the Massachusetts Agricultural College of the year 1890, and an efficient assistant in the chemical laboratory of the division of chemistry of the Experiment Station, who for several years in the past has attended to that part of the inspection in a very satisfactory manner.

Three hundred and twenty-eight samples were collected during the year, of which three hundred, representing two hundred and fifteen distinct brands, have been analyzed, and the results published in three bulletins, March, July and October, Numbers 38, 40 and 42 of the Hatch Experiment Station of the Massachusetts Agricultural College.

The modes of analyses adopted in this work were in all essential points those recommended by the Association of Official Chemists.

The results of the inspection have been on the whole quite satisfactory, as far as the compliance of the dealers with the provisions of our State laws for the regulation of the trade in commercial fertilizers is concerned. The variations here and there noticed between the guaranteed composition of the dealer and the results of our analyses could be traced with but few exceptions to imperfect mixing of the several ingredients of the fertilizer, and did not, as a rule, materially affect the commercial value of the article. In this connection attention should be called to the fact that the lowest amount stated in the guarantee is only legally binding.

To convey a more direct idea of the actual condition of this feature in the trade of commercial fertilizers of 1896, the following detailed statement is here inserted: —

(*a*) Where three essential elements of plant food were guaranteed: —

Number with three elements equal to or above the highest guarantee,	3
Number with two elements above the highest guarantee,	18
Number with one element above the highest guarantee,	65
Number with three elements between the lowest and highest guarantees,	26
Number with two elements between the lowest and highest guarantees,	60
Number with one element between the lowest and highest guarantees,	42
Number with two elements below the lowest guarantee,	8
Number with one element below the lowest guarantee,	59

(*b*) Where two essential elements of plant food were guaranteed: —

Number with two elements above the highest guarantee,	–
Number with one element above the highest guarantee,	16
Number with two elements between the lowest and highest guarantees,	13
Number with one element between the lowest and highest guarantees,	10
Number with one element below the lowest guarantee,	10

(*c*) Where one essential element of plant food was guaranteed: —

Number above the highest guarantee,	4
Number between the lowest and highest guarantees,	21
Number below the lowest guarantee,	11

The consumption of commercial fertilizers is steadily increasing, — a circumstance apparently not less due to a more general recognition of their good services, if judiciously selected and applied, than to gradual improvements in regard to their mechanical condition as well as their general chemical character. A noticeable change, referred to already in a previous report, regarding the chemical composition of many brands of so-called complete or formula fertilizers of to-day, as compared with those offered for similar purposes at an earlier period in the history of the trade in commercial fertilizers, consists in a more general and more liberal use of potash compounds as a prominent constituent. This change has been slow but decided, and in a large degree may be ascribed to the daily increasing evidence, resting on actual observations in the field and garden, that the farm lands of Massachusetts are quite frequently especially deficient in potash compounds, and consequently need in many instances a more liberal supply of available potash from outside sources to give satisfactory returns. Whenever the cultivation of garden vegetables, fruits and forage crops constitutes the principal products of the land, this recent change in the mode of manuring deserves in particular a serious trial; for the crops raised consume exceptionally large quantities of potash, as compared with grain crops. In view of these facts, it will be conceded that a system of manuring farm and garden which tends to meet more satisfactory recognized conditions of large areas of land, as well as the special wants of important growing branches of agricultural industries, is a movement in the right direction.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the raising of farm and garden crops of every description congenial to soil and climate. The various essential articles of plant food, as potash, phosphoric acid and nitrogen compounds, are freely offered for sale in forms suitable to render the different kinds of the home manurial refuse material of the farm in a higher degree fit to meet the special wants of the crops to be raised.

Mixed fertilizers, designed to supply the essential articles of plant food with reference to the needs of special crops,

and containing them in every conceivable proportion, are asking for the patronage of all parties interested in the raising of plants.

A judicious management of the trade in commercial fertilizers implies a due recognition of well-established experimental results regarding the requirements of a remunerative production of farm and garden crops; yet, as the manufacturer at best can only prepare the composition of his special fertilizers on general lines, not knowing the particular condition and character of the soil which ultimately receives them, it becomes of the utmost importance on the part of the farmer to make himself acquainted with his special wants of manurial substances, and to thus qualify himself for a more judicious selection from the various fertilizers offered for his patronage.

For the reason that the physical conditions and chemical resources of soils on available plant food are frequently differing widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil those plant constituents which the crops raised during preceding years have abstracted in an exceptionally large proportion, and which at the same time will be especially called for by the crops to be raised.

To select judiciously from among the agricultural chemicals and mixed fertilizers offered for sale for home use requires, in the main, three kinds of information: —

First. — A knowledge of the condition and the character of the soil to be prepared for cultivation.

Second. — An acquaintance with the composition of the crops, as far as the essential elements of plant food they contain are concerned.

Third. — A fair information regarding the general character, as well as the special composition, of the manurial substances offered for sale are concerned.

To assist as far as practicable in obtaining the above-stated desirable information, a compilation of the composition of our most prominent farm and garden crops, as well as the manurial substances and agricultural chemicals found in our markets, has been published from time to time in our annual reports, and will be found at the close of the present one.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in This State during the Past Year (May 1, 1896, to May 1, 1897), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Old Bog Cranberry Manure.

American Fertilizer Company, Boston, Mass.: —
- Anti Acid Phosphate.
- Alkaline Nitrate Phosphate for Hoed Crops.
- Alkaline Nitrate Phosphate for Hay and Grain Crops.
- Ward's Inodorous Plant Food.
- Muriate of Potash.

Wm. H. Abbott, Holyoke, Mass.: —
- Abbott's Fertilizer.
- Abbott's Eagle Brand Fertilizer.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.

H. J. Baker and Brother, New York, N. Y.: —
- Standard Un X Ld Fertilizer.
- Complete Strawberry Manure.
- Complete Onion Manure.
- Complete Potato Manure.
- Complete Corn Manure.
- A A Ammoniated Superphosphate.
- Complete Tobacco Manure.
- Grass and Lawn Dressing.
- Vegetable, Vine and Potato Special.
- Ground Bone.

C. A. Bartlett, Worcester, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.

The Berkshire Mills, Bridgeport, Conn.: —
Ammoniated Bone Phosphate.
Complete Fertilizer.

Bowker Fertilizer Company, Boston, Mass.: —
Stockbridge Special Manures.
Bowker's Hill and Drill Phosphate.
Bowker's Farm and Garden Phosphate.
Bowker's Lawn and Garden Dressing.
Bowker's Fish and Potash.
Bowker's Potato and Vegetable Manure.
Bowker's Market-garden Manure.
Bowker's Sure Crop Bone Phosphate.
Gloucester Fish and Potash.
Bowker's Dry Ground Fish.
Bowker's Fresh Ground Bone.
Nitrate of Soda.
Dried Blood.
Dissolved Bone-black.
Muriate of Potash.
Sulphate of Potash.
Sulphate of Ammonia.

Bradley Fertilizer Company, Boston, Mass.: —
Bradley's X L Superphosphate.
Bradley's Potato Manure.
Bradley's B D Sea Fowl Guano.
Bradley's Complete Manures.
Bradley's Fish and Potash.
Bradley's High-grade Tobacco Manure.
English Lawn Fertilizer.
Farmers' New Method Fertilizer.
Breck's Lawn and Garden Dressing.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Sulphate of Ammonia.
Dissolved Bone-black.
Fine-ground Bone.

William E. Brightman, Tiverton, R. I.: —
Brightman's Potato and Root Manure.
Brightman's Phosphate.
Brightman's Fish and Potash.

B. L. Bragg & Co., Springfield, Mass.: —
Hampden Lawn Dressing.

Butchers' Rendering Association, Saugus, Mass.: —
Ground Bone.
Champion Garden Fertilizer.

Daniel T. Church, Providence, R. I.: —
Church's B Special Fertilizer.
Church's C Standard Fertilizer.
Church's D Fish and Potash.

Clark's Cove Fertilizer Company, Boston, Mass.: —
Bay State Fertilizer.
Bay State Fertilizer, G G Brand.
Great Plant Manure.
Potato and Tobacco Manure.
King Philip Guano.
Potato Manure.
Fish and Potash.
White Oak Pure Ground Bone.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.

The Cleveland Dryer Company, Boston, Mass.: —
Cleveland Superphosphate.
Cleveland Potato Phosphate.
Cleveland Fertilizer.

E. Frank Coe Company, New York, N. Y.: —
E. Frank Coe's Excelsior Potato Fertilizer.
E. Frank Coe's High-grade Potato Fertilizer.
E. Frank Coe's Special Fertilizer.
E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
E. Frank Coe's Fish Guano and Potash.
E. Frank Coe's Bay State Ammoniated Bone Superphosphate.
E. Frank Coe's Bay State High-grade Potato Fertilizer.

Crocker Fertilizer and Chemical Company, Buffalo, N. Y.: —
Crocker's General Crop Phosphate.
Crocker's New England Tobacco Grower.

Crocker Fertilizer and Chemical Company, Buffalo, N. Y. — *Concluded.*

Muriate of Potash.
Coolidge Brothers' Special Truck Fertilizer.
Crocker's Ammoniated Bone Superphosphate.
Crocker's Potato, Hop and Tobacco Phosphate.
Crocker's Special Potato Manure.
Crocker's Pure Ground Bone.
Crocker's Practical Ammoniated Superphosphate.
Crocker's New Rival Ammoniated Superphosphate.
Crocker's Ammoniated Wheat and Corn Phosphate.
Crocker's Ground Bone Meal.
Crocker's Vegetable Bone Superphosphate.

Cumberland Bone Phosphate Company, Boston, Mass.: —

Cumberland Superphosphate.
Cumberland Potato Fertilizer.
Cumberland Concentrated Phosphate.
Cumberland Fertilizer.

L. B. Darling Fertilizer Company, Pawtucket, R. I.: —

Animal Fertilizer.
Extra Bone Phosphate.
Potato and Root Fertilizer.
Lawn and Garden Fertilizer.
Tobacco Grower.
Pure Fine Bone.
Pure Dissolved Bone.
Sulphate of Potash.

John C. Dow & Co., Boston, Mass.: —

Superphosphate.
Pure Bone.
Bone Fertilizer.

Fyfe, Fay & Plummer, Clinton, Mass.: —

Canada Wood Ashes.

Great Eastern Fertilizer Company, Rutland, Vt.: —

Great Eastern General Fertilizer.
Northern Corn Special.
Soluble Bone and Potash.
Vegetable, Vine and Tobacco Fertilizer.
Garden Special Fertilizer.

Thomas Hersom & Co., New Bedford, Mass. : —
Bone Meal.

John G. Jefferds, Worcester, Mass. : —
Jefferds' Fine Ground Bone.
Jefferds' Potato Manure.
Jefferds' Animal Fertilizer.

Thomas Kirley, South Hadley Falls, Mass. : —
Kirley's Pride of the Valley.

A. Lee & Co., Lawrence, Mass. : —
The Lawrence Fertilizer.

Lowell Fertilizer Company, Lowell, Mass. : —
Lowell Bone Fertilizer.
Lowell Animal Fertilizer.
Lowell Potato Phosphate.
Lowell Vegetable and Vine Fertilizer.
Lowell Lawn Dressing.
Dissolved Bone and Potash.
Complete Manure for Potatoes and Vegetables.

Lowe Brothers & Co., Fitchburg, Mass. : —
Tankage.

The Mapes Formula and Peruvian Guano Company, New York, N. Y. : —
The Mapes Superphosphates.
The Mapes Bone Manures.
The Mapes Special Crop Manures.
Sulphate of Potash.
Double Manure Salts.
Nitrate of Soda.
Economical Manure.
Lawn Top-dressing with Plaster.

E. McGarvey & Co., successors to Forest City Wood Ash Company, Boston, Mass. : —
Unleached Wood Ashes.

McQuade Brothers, West Auburn, Mass. : —
Pure Ground Bone.

Monroe, Lalor & Co., Oswego, N. Y.: —
Unleached Wood Ashes.

National Fertilizer Company, Bridgeport, Conn.: —
Chittenden's Complete Fertilizers.
Chittenden's Ammoniated Bone.
Chittenden's Market-garden Fertilizer.
Chittenden's Fish and Potash.
Chittenden's Ground Bone.
Chittenden's Potato Phosphate.

Niagara Fertilizer Company, Buffalo, N. Y.: —
Niagara Wheat and Corn Producer.
Niagara Triumph.
Niagara Grain and Grass Fertilizer.
Niagara Potato, Tobacco and Hop Fertilizer.

Packers' Union Fertilizer Company, New York, N. Y.: —
Animal Corn Fertilizer.
University Fertilizer.
Oats and Clover Fertilizer.
Potato Manure.
Gardeners' Complete Manure.

Pacific Guano Company, Boston, Mass.: —
Soluble Pacific Guano.
Special Potato Manure.
Nobsque Guano.
Special for Potatoes and Tobacco.
Fish and Potash.
High-grade General Fertilizer.

Parmenter & Polsey Fertilizer Company, Peabody, Mass.: —
Plymouth Rock Brand.
Special Potato Fertilizer.
Special Strawberry Manure.
Star Brand Fertilizer.
Lawn Dressing.
Ground Bone.
Nitrate of Soda.
Muriate of Potash.

E. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.
- Fish and Potash.
- Dry Ground Fish.

Preston Fertilizer Company, Green Point, L. I.: —
- Pioneer Fertilizer.
- Ammoniated Superphosphate.
- Potato Fertilizer.

Quinnipiac Company, Boston, Mass.: —
- Potato Manure.
- Market-garden Manure.
- Ammoniated Dissolved Bones.
- Fish and Potash (Crossed Fishes).
- Fish and Potash (Plain Brand).
- Havana Tobacco Fertilizer.
- Grass Fertilizer.
- Corn Manure.
- Potato and Tobacco Fertilizer.
- Onion Manure.
- Pure Bone Meal.
- Dry Ground Fish.
- Tankage.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.
- Phosphate.

Read Fertilizer Company, New York, N. Y.: —
- Read's Standard.
- High-grade Farmers' Friend.
- Fish and Potash.
- Vegetable and Vine Fertilizer.
- Practical Potato Special Fertilizer.

N. Roy & Son, South Attleborough, Mass. : —
Complete Animal Fertilizer.

The Rogers & Hubbard Company, Middletown, Conn. : —
Pure Raw Knuckle Bone Flour.
Strictly Pure Fine Bone.
Soluble Potato Manure.
Soluble Tobacco Manure.
Fertilizer for Oats and Top-dressing.
Fairchild's Formula for Corn and General Crops.
Grass and Grain Fertilizer.

Russia Cement Company, Gloucester, Mass. : —
XXX Fish and Potash.
High-grade Superphosphate.
Special Manure for Potatoes, Roots and Vegetables.
Special Manure for Corn, Grain and Grass.
Odorless Lawn Dressing.
Dry Ground Fish.

Lucien Sanderson, New Haven, Conn. : —
Dissolved Bone-black.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.
Blood, Meat and Bone.
Formula A.

M. L. Shoemaker & Co., Limited, Philadelphia, Penn. : —
Swift and Sure Phosphate.
Swift and Sure Bone Meal.

Edward H. Smith, Northborough, Mass. : —
Fine-ground Bone.

Standard Fertilizer Company, Boston, Mass. : —
Standard Fertilizer.
Potato and Tobacco Fertilizer.
Standard Guano.
Fine-ground Bone.
Complete Manure.

Thomas L. Stetson, Randolph, Mass. : —
Fine-ground Bone.

F. C. Sturtevant, Hartford, Conn. : —
Ground Tobacco Stems.

Henry F. Tucker & Co., Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.

Walker, Stratman & Co., Pittsburg, Penn.: —
Potato Special.
Four Fold.
Smoky City.
Meadow King.

I S. Whittemore, Wayland, Mass.: —
Whittemore's Complete Manure.

The Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Tobacco Manure.
Ammoniated Bone Phosphate.
High-grade Fish and Potash.
Dry Ground Fish Guano.
Fish and Potash, 1896 Brand.
Low-grade Sulphate of Potash.

Williams & Clark Fertilizer Company, Boston, Mass.: —
Superphosphate.
Potato Phosphate.
High-grade Special.
Fine Wrapper Tobacco Fertilizer.
Royal Bone Phosphate.
Corn Phosphate.
Potato and Tobacco Manure.
Grass Manure.
Fish and Potash.
Universal Ammoniated Dissolved Bone.
Prolific Crop Producer.
Onion Manure.
Pure Bone Meal.
Dry Ground Fish.
Tankage.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.
Dissolved Bone-black.
Sulphate of Ammonia.

M. E. Wheeler & Co., Rutland, Vt.: —
- High-grade Fruit Fertilizer.
- Grass and Oats Fertilizer.
- Electrical Dissolved Bone.
- Potato Manure.
- High-grade Corn Fertilizer.
- Superior Truck Fertilizer.

2. New Laws for the Regulation of the Trade in Commercial Fertilizers in Massachusetts.

[Acts of 1896, Chapter 297.]

An Act to regulate the Sale of Commercial Fertilizers.

Be it enacted, etc., as follows:

Section 1. Every lot or parcel of commercial fertilizer or fertilizer material sold or offered or exposed for sale within this Commonwealth shall be accompanied by a plainly printed statement, clearly and truly certifying the number of net pounds of fertilizer in the package, the name, brand or trade-mark under which the fertilizer is sold, the name and address of the manufacturer or importer, the location of the factory, and a chemical analysis stating the percentage of nitrogen, of potash soluble in distilled water, and of phosphoric acid in available form soluble in distilled water and reverted, as well as the total phosphoric acid. In the case of those fertilizers which consist of other and cheaper materials said label shall give a correct general statement of the composition and ingredients of the fertilizer it accompanies.

Sect. 2. Before any commercial fertilizer is sold or offered or exposed for sale the importer, manufacturer or party who causes it to be sold or offered for sale within this Commonwealth shall file with the director of the Hatch experiment station of the Massachusetts Agricultural College a certified copy of the statement named in section one of this act, and shall also deposit with said director at his request, a sealed glass jar or bottle, containing not less than one pound of the fertilizer, accompanied by an affidavit that it is a fair average sample thereof.

Sect. 3. The manufacturer, importer, agent or seller of any brand of commercial fertilizer or fertilizer material shall pay for each brand, on or before the first day of May annually, to the director of the experiment station, an analysis fee of five dollars for each of the three following fertilizing ingredients: namely, nitrogen, phosphorus and potassium, contained or claimed to exist in said brand of fertilizer: *provided*, that whenever the manufact-

urer or importer shall have paid the fee herein required for any person acting as agent or seller for such manufacturer or importer, such agent or seller shall not be required to pay the fee named in this section: and on receipt of said analysis fees and statement specified in section two the director of said station shall issue certificates of compliance with this act.

SECT. 4. No person shall sell or offer or expose for sale in this Commonwealth any pulverized leather, hair or wool waste, raw, steamed, roasted or in any form as a fertilizer, or as an ingredient of any fertilizer or manure, without an explicit printed certificate of the fact, said certificate to be conspicuously affixed to every package of such fertilizer or manure, and to accompany or go with every parcel or lot of the same.

SECT. 5. Any person selling or offering or exposing for sale any commercial fertilizer without the statement required by the first section of this act, or with a label stating that said fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, or respecting the sale of which all the provisions of the foregoing section have not been fully complied with, shall forfeit fifty dollars for the first offence and one hundred dollars for each subsequent offence.

SECT. 6. This act shall not affect parties manufacturing, importing or purchasing fertilizers for their own use and not to sell in this Commonwealth.

SECT. 7. The director of the experiment station shall pay the analysis fees, as soon as received by him, into the treasury of the station, and shall cause one analysis or more of each fertilizer or fertilizer material to be made annually, and shall publish the results from time to time, with such additional information as the circumstances render advisable, provided such information relates only to the composition of the fertilizer or fertilizer material inspected. Said director is hereby authorized in person or by deputy to take a sample, not exceeding two pounds in weight, for analysis, from any lot or package of fertilizer or fertilizer material which may be in the possession of any manufacturer, importer, agent or dealer; but said sample shall be drawn in the presence of said party or parties in interest, or their representative, and taken from a parcel or a number of packages which shall be not less than ten per cent. of the whole lot inspected, and shall be thoroughly mixed and then divided into two equal samples and placed in glass vessels, and carefully sealed and a label placed on each, stating the name or brand of the fertilizer or material sampled, the name of the party from whose stock the sample was

drawn, and the time and place of drawing; and said label shall also be signed by the director or his deputy and by the party or parties in interest, or their representatives present at the drawing and sealing of said sample; one of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled. All parties violating this act shall be prosecuted by the director of said station.

SECT. 8. Chapter two hundred and ninety-six of the acts of the year eighteen hundred and eighty-eight is hereby repealed.

SECT. 9. This act shall take effect on the first day of November in the year eighteen hundred and ninety-six. [*Approved April 17, 1896.*]

3. General Work in the Chemical Laboratory.

Analyses of materials sent on for examination.

Notes on basic phosphatic slag ("slag meal") as a fertilizer.

Action of chloride of potassium (muriate of potash) and chloride of sodium (common salt) on the lime resources of the soil.

Effect of chloride of potassium on sulphate of ammonium in mixed fertilizers.

Analyses of Materials sent on for Examination.

The constantly increasing variety of waste products of many branches of industry within our State and elsewhere, which have proved of manurial value, has received for years a serious attention. As a change in the current modes of manufacture of the parent industry is at any time liable to seriously affect the character and chemical composition of the waste or by products, it becomes necessary to repeat from time to time analyses of many of these products. These analyses are made, as far as our resources allow, without any charge for the work, on the condition that the results are public property if deemed of interest for publication.

A brief enumeration of the more prominent substances sent on for our investigation during the year 1896 may serve to convey a correct idea concerning the extent and importance of the labor involved. The whole number of substances analyzed in this connection during the year 1896 to December 1 amounts to 175: wood ashes, 51; cotton-seed-hull ashes, 7; swill ashes from cremation furnace, 1; rock phosphate, 4; acid phosphate, 4; phosphatic slag, 2; ground bones, tank-

age, dried fish and blood, 18; cotton-seed and linseed meal, 19; barn-yard manure, solid and liquid, 11; cotton waste from factories, 6; potash salts of various descriptions, 18; dry Bordeaux mixtures, 10; Paris green, 8; miscellaneous analyses, 10; and compound fertilizers, 21.

The responsibility of the genuineness of all samples sent on for examination rests with the parties asking for analyses; the name of the localities they come from appears only in our published records of the work to prevent misunderstandings. The samples of fertilizers collected by responsible parties under the direction of the officer of this department alone are entered on our list of official analyses.

Notes on Basic Phosphatic Slag ("Slag Meal") as a Fertilizer.

This article appeared for the first time in our markets in 1886 under the name of phosphatic meal made of the Peine-Thomas Scoria, a by-product of a new process introduced into the manufacture of iron and steel from phosphorus containing iron ores.

The first sample received by me at Amherst was marked "R. Weichsel & Co., Magdeburg, Germany; phosphate meal made of the Peine-Thomas Scoria, guaranteed by Dr. Ulex of Hamburg, Germany, to contain 21.41 per cent. of phosphoric acid, corresponding to 46.74 per cent. of bone phosphate; Paul Weidinger & Co., New York, acting as agents."

The first lot sent on for field experiments consisted of 500 pounds of ground slag meal, also a mixture of 500 pounds of slag meal with 500 pounds of kainite; to the latter had been added some dry ground peat, to prevent caking. Pure slag meal, it is claimed, never hardens after being ground.

As the process of dephosphorizing the iron requires that the slag should be alkaline from the beginning, an excess of lime enters into the composition of the slag. To the presence of a certain amount of burned lime the phosphate meal owes, evidently, some of its good effects as a phosphoric acid source for plant food; incorporated in the soil, it absorbs moisture, and, like burned lime, it breaks up into an impal-

pable powder, which cannot fail to increase the availability of its phosphoric acid in a marked degree, as compared with other non-acidulated ground phosphates.

Not less beneficial must be considered in many instances the alkaline reaction of the genuine material, for it secures favorable conditions not only for a rapid decomposition ("nitrification") of the organic matter of the soil, but also for the disintegration of valuable mineral constituents of the soil, rendering in both directions inherent plant food more available. Much attention has been paid in Germany and England to experiments with slag meal as a phosphoric acid source of plant food, and many satisfactory results are reported. Our own observations are, to say the least, very encouraging, as may be seen from several annual reports since 1887.

Mixtures of phosphatic slag with nitrate of soda and the higher grades of potash salts have given in many instances much satisfaction. To secure the full benefit of the action of slag meal, it is desirable to scatter it broadcast late in the fall or early in the spring, and to plough it under at once from three to four inches; nitrate of soda and potash salts may be harrowed in later on, previous to seeding down.

The high price (from $20 to $25 per ton) of late charged for phosphatic slag meal of a varying composition and general character has discouraged its trial, as compared with the ground phosphate of South Carolina and Florida. As the high price has greatly interfered with a more general trial of slag meal, it is of interest to learn that arrangements are announced which will result in introducing large supplies of it at a much lower cost than before. A German syndicate, claiming to own the right of patent regarding the sale of Thomas slag in Europe and the United States, has established an office in Philadelphia, Penn., address Charles A. Voight, P. O. box 2133, Station A. In a recent communication from him it is stated the article will be offered for sale at from $8 to $9 per ton to farmers in the eastern States. The material consists of a dark, fine powder; it is sent out in 200 pound bags, with a guarantee of 18 per cent. of phosphoric acid. The station has secured a quantity for trial during the coming season.

Analysis of Phosphatic Slag Meal.

[I. Analyses of above-stated sample, 1896; II. Average of four analyses of earlier dates.]

	Per Cent.	
	I.	II.
Moisture,	1.45	1.45
Total phosphoric acid,	17.88	23.49
Calcium oxide (lime),	43.74	48.66
Magnesium oxide,	-*	3.42
Ferric and aluminic oxides,	25.25	10.12
Insoluble matter,	9.93	9.40

* Not determined.

Action of Chloride of Potassium (Muriate of Potash) and Chloride of Sodium (Common Salt) on the Lime Resources of the Soil.

In a previous bulletin, No. 38, issued March, 1896, by the Hatch Experiment Station, I called attention to an observation in connection with some field experiments, which showed that in several instances where, under otherwise corresponding circumstances, for several years muriate of potash had been liberally used as a potash source for a variety of crops, instead of sulphate of potash, an unhealthy appearance and lower yield of crop became from year to year more apparent. To correct this feature, from 350 to 400 pounds per acre of dry slacked lime were scattered broadcast over the surface of the soil, and ploughed under before manuring and seeding down the crop. The addition of lime gave excellent satisfaction, for the new crop looked healthy and vigorous, and the yield of the crop increased again fully to the average amount of the field. An examination of the drainage waters confirmed the view taken in the treatment of the field; the chlorides of calcium and magnesium were noticed to form prominent constituents of the

solid residue left after its evaporation. The amount of lime noticed in the drainage waters where muriate of potash had been added as a potash source was in every instance larger than where corresponding amounts of high-grade sulphate of potash were applied.

In publishing the results of our observations the following conclusions were offered for the consideration of farmers: —

(*a*) *The claim of both muriate and sulphate of potash, being economical and efficient forms to supply potash for growing crops, is so well established that no further endorsement is called for in this connection. Each form has its special merits with reference to particular fitness in case of different crops.*

(*b*) *The liberal use of muriate of potash as a fertilizer constituent renders, in cases where the lime resources of the soil under cultivation are limited, a periodical direct application of lime compounds as a manurial matter advisable.*

(*c*) *Muriate of potash is a safer source for manurial purposes upon a deep soil with a free subsoil than upon a shallow soil with a compact clayish subsoil, on account of a possible accumulation of the highly objectionable chlorides of calcium and magnesium (lime and magnesia) near the roots of the plants; both are known to prevent a healthy development of the root system.*

Repeated observations in the field and in the laboratory tend to confirm the above-stated conclusions; chloride of sodium (common salt) behaves in the same way as the chloride of potassium, — a fact which is readily proved by adding to any kind of a soil which is free from the chlorides of calcium some ground chalk and common salt, and after a week or so collecting and analyzing the percolating water; the presence of carbonic acid favors greatly the reaction; no good agricultural soil is free from carbonic acid or bicarbonates of lime and magnesium.

Effect of Chloride of Potassium (Muriate of Potash) on Sulphate of Ammonium in Mixed Fertilizers.

In studying the influence of the following mixtures of fertilizing materials, *i. e.*, —

PLATS.	Annual Supply of Manurial Substances.	Pounds.
Plat 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

on the yield and character of a variety of garden crops, it was noticed, with but one or two exceptions, that the fertilizers on Plat 1, consisting of dissolved bone-black, sulphate of ammonium and muriate of potash, produced the lowest yield of crop on trial; while the fertilizers on Plat 4, composed of corresponding quantities of dissolved bone-black, sulphate of ammonium and high-grade sulphate of potash, yielded, as a rule, a fair average crop. (For details, see preceding annual reports since 1892.)

As the season, character of the soil and mode of cultivation were practically the same in all cases, it seemed but natural to conclude that the fertilizers applied to Plat 1 suffered an unfavorable change when incorporated in the soil. An actual trial proved that a dry mixture of muriate of potash and sulphate of ammonium dissolved in water changes into sulphate of potash and chloride of ammonium (sal ammoniac); this form of nitrogen is known to act unfavorably on growing plants.

Most of our agricultural chemicals are liable to suffer chemical changes when used in mixed fertilizers; these changes are frequently not less depending on a mutual reac-

tion upon each other than on the general character and the particular chemical composition of the soil which receives them. The results of the chemical reactions between the saline constituents of the fertilizers and of the soil are as apt to benefit the crop as to injure it; the above-described observation furnishes an illustration of an injurious influence. Sulphate of ammonium is evidently a safer source of nitrogen for plant growth when used in connection with sulphate of potash than when used with muriate of potash (chloride of potassium).

4. Compilation of Analyses of Agricultural Chemicals, Manurial Substances, Fruits, Garden Crops and Insecticides.

Prepared by H. D. Haskins, Assistant Chemist, Hatch Experiment Station.

1868 to 1897.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the reports of the State Inspector of Fertilizers from 1873 to 1896, contained in the reports of the Secretary of the Massachusetts State Board of Agriculture for those years, and in the bulletins of the department of chemistry of the Hatch Experiment Station of the Massachusetts Agricultural College since March, 1895.

As the basis of valuation changes from year to year, no valuation is stated in this compilation.

C. A. GOESSMANN.

	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc.																							
Muriate of potash,	81	1.77	-	-	-	-	58.98	45.94	51.00	-	-	-	-	-	-	6.69	-	.55	-	-	-	48.80	.70
Sulphate of potash,	38	1.86	-	-	-	-	51.30	21.36	40.21	-	-	-	-	-	-	4.46	-	1.50	-	45.72	-	-	.75
Sulphate of potash-magnesia,	28	4.81	-	-	-	-	29.48	16.96	24.82	-	-	-	-	-	-	6.25	2.57	-	-	44.25	-	2.60	1.41
Carbonate of potash,	1	26.88	-	-	-	-	-	-	18.48	-	-	-	-	-	-	-	-	10.52	-	-	-	-	.39
Phosphate of potash,	1	3.76	-	-	-	-	-	-	32.56	-	-	37.50	-	-	-	-	-	-	-	13.43	-	-	.92
Kainite,	5	3.18	-	-	-	-	16.48	12.51	13.56	-	-	-	-	-	-	18.97	1.15	9.80	-	20.25	-	33.25	2.13
Carnallite,	1	-	-	-	-	-	-	-	13.68	-	-	-	-	-	-	7.66	-	13.19	-	.56	-	41.56	-
Krugite,	1	4.82	-	-	-	-	-	-	8.42	-	-	-	-	-	-	5.27	12.45	8.79	-	31.94	-	6.63	14.96
Sulphate of magnesia (Kieserite),	9	22.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.82	17.30	-	36.10	-	-	5.73
Nitrate of potash,	4	1.30	-	14.58	11.60	12.71	45.62	44.76	45.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate of soda,	37	1.38	-	16.22	14.28	15.04	-	-	-	-	-	-	-	-	-	35.50	-	-	-	-	-	.50	.50
Sulphate of ammonia,	28	1.06	-	21.68	19.59	22.03	-	-	-	-	-	-	-	-	-	-	-	-	-	60.00	-	-	-
Phosphate of ammonia,	1	6.05	-	-	-	10.37	-	-	-	-	-	43.86	-	-	-	-	-	-	-	12.46	-	-	.82
Sulphate of soda,	1	1.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.43	-	-	-
Saltpetre waste,	12	2.54	-	3.30	.52	2.22	30.94	1.55	13.66	-	-	-	-	-	-	37.04	.75	.19	-	1.85	-	46.25	-
Nitre salt-cake,	2	6.03	-	-	-	2.29	-	-	.87	-	-	-	-	-	-	29.56	-	-	-	47.77	-	-	3.92

Wood ashes,	527	10.38	-	-	-	-	10.80	1.20	5.39	5.58	.05	1.51	-	-	-	-	33.55	3.31	.96	-	-	-	16.28
Cotton-seed-hull ashes,	56	8.60	-	-	-	-	42.12	9.08	22.55	22.38	2.89	8.59	-	-	-	-	9.39	10.47	1.76	-	-	-	13.44
Ashes of spent tan-bark,	5	4.84	-	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	-	-	31.11	3.39	1.78	-	-	-	25.21
Corn-cob ashes,	1	1.20	-	-	-	-	-	-	7.08	-	-	2.37	-	-	-	-	11.70	-	1.28	-	-	-	52.09
Railroad-tie ashes,	1	4.70	-	-	-	-	-	-	.92	-	-	.56	-	-	-	-	2.51	-	-	-	-	-	80.20
Peat ashes,	1	4.67	-	-	-	-	-	-	.46	-	-	.11	-	-	-	-	2.28	1.63	6.13	-	-	-	45.17
Logwood ashes,	1	1.50	-	-	-	-	-	-	.08	-	-	2.30	-	-	-	-	3.90	-	-	-	-	-	9.70
Hard-pine wood ashes,	1	.75	-	-	-	-	-	-	10.16	-	-	2.24	-	-	-	-	24.95	-	-	-	-	-	29.90
Mill ashes,	1	.53	-	-	-	-	-	-	1.60	-	-	.46	-	-	-	-	34.93	1.35	-	-	-	-	36.36
Ashes from cremation of swill,	15	4.86	-	-	-	-	8.83	1.25	3.97	32.36	7.47	14.16	-	-	-	-	33.58	1.87	4.65	-	-	-	21.57
Ashes from blue works,	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30
Sea-weed ashes,	1	1.47	-	-	-	-	-	-	.92	-	-	.30	-	-	-	8.76	6.06	4.37	-	2.98	-	6.60	63.65
Gypse,	1	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.87	-	-	-	-	-	2.87
Nova Scotia plaster (gypsum),	16	8.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.85	.75	-	44.87	-	-	3.47
Onondaga plaster (New York gypsum),	4	13.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.00	4.66	-	32.50	8.20	-	9.83
Lime,	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.63	-	-	-	-	-	1.33
Waste lime,	1	.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74.12	-	-	-	-	-	.38
Gas-house lime,	3	22.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.66	8.30	-	20.73	-	-	6.05
Lime waste from sugar factory,	1	36.30	-	-	-	-	-	-	.22	-	-	2.25	-	-	-	-	27.51	-	-	-	-	-	.32
Lime kiln ashes,	17	14.48	-	-	-	-	2.78	.02	1.28	3.16	.36	1.09	-	-	-	-	42.57	2.60	-	-	17.75	-	7.69
Bituminous coal ashes,	2	3.66	-	-	-	-	-	-	.38	-	-	.44	-	-	-	-	1.88	-	-	-	-	-	74.17
Carbonate of lime,	1	.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.98	-	-	-	-	-	-

	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc. — Concluded.																							
Marls (Massachusetts),	7	13.70	-	-	-	-	-	-	.24	2.72	.06	1.05	-	-	-	-	40.50	.64	.69	-	28.57	-	3.44
Marls (Virginia),	2	15.98	-	-	-	-	.61	.37	.49	.09	.08	.09	-	-	-	-	7.25	.21	-	.66	7.25	-	64.23
Green sand marl (Virginia),	1	1.25	-	-	-	-	-	-	1.14	-	-	9.37	-	-	-	-	25.78	-	5.13	-	-	-	41.32
Olive earth (Virginia),	1	1.97	-	-	-	-	-	-	.24	-	-	13.73	-	-	-	-	19.16	-	6.00	-	-	-	50.55
Ammoniated marl,	1	3.31	-	-	-	1.61	-	-	-	-	-	10.39	-	.41	9.98	-	-	-	-	-	-	-	-
Marl (North Carolina),	1	1.50	-	-	-	-	-	-	.04	-	-	.56	-	-	-	-	21.95	.61	-	-	-	-	50.18
Clay (so called),	1	.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	54.35	1.04	2.80	-	37.32	-	2.57
II. Guanos, Phosphates, etc.																							
Peruvian guano,	26	14.81	37.61	13.50	4.44	7.85	4.08	1.14	2.61	20.60	5.96	15.26	4.57	3.79	6.90	-	-	-	-	-	-	-	6.60
Bat guano from Texas,	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	-	-	-	2.00
Bat guano from Florida,	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	-	-	-	19.33
Rat guano from Florida,	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15
Cuban guano,	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	-	-	-	3.17
Caribbean guano (orchilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.11	26.77	-	-	-	-	39.95	3.29	-	2.68	-	-	1.27
Mona Island guano,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	-	-	-	2.45

South Carolina rock phosphate,	7	1.30	-	-	-	-	-	-	-	30.51	24.70	27.42	.27	.07	27.13	-	41.87	3.03	4.80	-	-	-	9.04
South Carolina floats,	1	.83	-	-	-	-	-	-	-	-	-	23.39	-	2.33	21.06	-	-	-	-	-	-	-	20.16
Florida rock phosphate,	31	2.00	-	-	-	-	-	-	.21	38.97	6.95	26.02	-	1.47	19.70	-	30.40	-	7.68	-	2.08	-	27.29
Soft Florida phosphate,	3	4.87	-	-	-	-	-	-	-	19.94	17.71	18.73	-	-	-	-	23.72	-	6.82	-	-	-	20.92
Navassa phosphate,	2	7.60	-	-	-	-	-	-	-	34.45	34.09	34.27	-	-	-	-	37.45	-	10.27	-	-	-	2.70
Brockville phosphate,	1	2.50	-	-	-	-	-	-	-	-	-	35.21	-	-	-	-	-	-	-	-	-	-	6.46
Phosphatic slag,	4	1.45	-	-	-	-	-	-	-	30.51	18.91	23.49	-	3.06	21.65	-	48.66	3.42	10.12	-	-	-	9.40
Odorless phosphate,	6	2.99	-	-	-	-	.52	.04	.38	21.74	18.40	19.54	-	.52	19.82	-	51.42	-	-	-	2.51	-	9.14
Dissolved bone-black,	7	10.17	47.50	-	-	-	-	-	-	17.80	14.99	16.25	15.61	1.15	.37	-	-	-	-	-	-	-	3.99
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-	-	-
Bone-black,	5	4.60	-	-	-	-	-	-	-	30.54	16.56	28.28	-	-	-	-	-	-	-	-	-	-	3.64
Double superphosphate,	1	5.74	-	-	-	-	-	-	-	-	-	47.80	38.38	9.04	.38	-	16.00	-	-	1.19	-	-	.60
South American bone-ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	4.50
Acid phosphate,	1	14.23	69.95	-	-	-	-	-	-	-	-	14.64	10.34	2.42	1.88	-	-	-	-	-	-	-	10.81
III. Refuse Substances.																							
Dried blood,	19	11.43	6.37	13.55	8.10	10.43	-	-	-	8.70	1.30	2.64	-	-	-	-	-	-	-	-	-	-	-
Ammonite,	1	5.88	-	-	-	11.33	-	-	-	-	-	3.43	-	-	-	-	-	-	-	-	-	-	1.38
Oleomargarine refuse,	1	8.54	14.42	-	-	12.12	-	-	-	-	-	.88	-	-	-	-	-	-	-	-	-	-	.96
Felt refuse,	1	29.24	33.53	-	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sponge refuse,	1	7.25	-	-	-	2.43	-	-	-	-	-	3.19	-	-	-	-	3.94	1.27	-	-	-	-	39.05
Blood and bone,	2	8.36	-	6.80	6.08	6.74	-	-	-	11.39	10.62	11.01	-	2.82	7.80	-	-	-	-	-	-	-	-
Horn shavings,	1	4.83	-	-	-	15.31	-	-	-	-	-	.42	-	-	-	-	-	-	-	-	-	-	-

	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
III. Refuse Substances — Continued.																							
Ivory dust,	1	11.50	52.63	-	-	6.64	-	-	-	-	-	24.56	.97	17.97	5.62	-	-	-	-	-	-	-	-
Horn and hoof waste,	3	10.17	7.63	15.49	11.84	13.25	-	-	-	2.30	1.36	1.83	-	-	-	-	-	-	-	-	-	-	.24
Raw wool,	1	6.95	7.54	-	-	12.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.63
Wool waste,	11	11.77	24.10	10.20	.96	4.56	3.50	.06	1.68	.67	.05	.31	-	-	-	-	.11	.06	.80	-	-	-	8.20
Wool washings (water),	1	-	-	-	-	-	-	-	3.92	-	-	-	-	-	-	.49	.28	-	-	-	-	-	-
Wool washings (acid),	1	-	-	-	-	-	-	-	4.20	-	-	-	-	-	-	.40	.61	.20	-	-	-	-	-
Wool washings (alkaline),	1	92.03	3.28	-	-	.09	-	-	1.09	-	-	-	-	-	-	.92	.04	-	-	-	-	-	.22
Morocco factory waste,	1	22.72	-	-	-	1.16	-	-	.36	-	-	2.56	-	-	-	-	19.60	-	-	1.24	-	-	24.17
Meat scrap,	2	24.79	-	-	-	6.33	-	-	-	-	-	5.79	-	-	-	-	-	-	-	-	-	-	-
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	-	-	-	3.58	.56	2.07	-	-	-	-	-	-	-	-	-	-	.58
Bone soup,	1	82.92	7.07	-	-	1.14	-	-	-	-	-	1.26	-	-	-	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	1	14.80	8.40	-	-	9.97	-	-	-	-	-	.53	-	-	-	-	-	-	-	-	-	-	.64
Dried soup from rendering cattle feet,	1	10.80	7.50	-	-	14.47	-	-	-	-	-	.46	-	-	-	-	-	-	-	-	-	-	.26
Dried soup from horse rendering,	1	92.14	-	-	-	1.12	-	-	-	-	-	.14	-	-	-	-	-	-	-	-	-	-	-
Soap-grease refuse,	2	29.25	51.39	4.20	2.21	3.21	-	-	-	15.37	11.04	13.21	-	-	-	-	-	-	-	-	-	-	1.29
Bones,	170	6.76	53.03	4.70	1.57	3.87	-	-	-	32.52	15.16	22.43	.38	8.62	13.77	-	-	-	-	-	-	-	1.08

Meat and bone, ...	2	5.26	-	-	-	4.57	-	-	-	-	-	20.21	.26	7.03	13.05	-	-	-	-	-	-	-	1.22
Tankage, ...	19	8 20	-	9.16	2.66	6.14	-	-	-	24.30	1.72	12.84	-	4.06	7.46	-	-	-	-	-	-	-	-
Fish with less than twenty per cent. water,	73	12.18	21.50	11.40	5.97	7.58	-	-	-	15.91	5.50	8.48	.55	2.64	5.06	-	-	-	-	-	-	-	2.01
Fish with between twenty and forty per cent. water.	10	30.19	20.59	7.41	4.22	5.97	-	-	-	8.32	4.68	7.09	.74	2.69	3.64	-	-	-	-	-	-	-	1.68
Fish with more than forty per cent. water,	10	45.46	15.50	7.60	2.43	4.97	-	-	-	8.56	2.94	5.08	1.17	1.33	2.58	-	-	-	-	-	-	-	1.35
Whale meat, raw, ...	1	44.50	1.04	-	-	4.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobster shells, ...	1	7.27	-	-	-	4.50	-	-	-	-	-	3.52	-	-	-	-	22.24	1.30	-	-	-	-	.27
Castor-bean pomace, ...	6	9.68	5.70	5.72	5.22	5.51	3.40	.64	1.57	2.26	1.57	2.18	-	-	-	-	.87	.29	-	-	-	-	1.75
Cotton-seed meal, ...	50	7.05	5.78	7.95	2.05	6.60	2.38	.48	1.76	3.36	.73	1.79	-	-	-	-	-	-	-	-	-	-	.28
Linseed meal, ...	2	8.43	-	-	-	6.34	-	-	1.25	-	-	1.84	-	-	-	-	-	-	-	-	-	-	-
Rotten brewers' grain, ...	1	78.77	-	-	-	.72	-	-	.04	-	-	.43	-	-	-	-	.26	.15	-	-	-	-	.59
Mill sweepings, ...	1	9.49	-	-	-	3.76	-	-	.66	-	-	1.18	-	-	-	-	-	-	-	-	-	-	5.01
Tobacco leaf, ...	1	13.05	21.01	-	-	2.75	-	-	7.24	-	-	.43	-	-	-	-	4.17	2.17	.32	-	-	-	4.17
Tobacco stems, ...	7	10.61	14.07	2.91	.90	2.30	10.60	3.76	7.03	2.09	.44	.62	-	-	-	.34	3.89	1.23	-	-	-	-	.82
Cotton waste, wet, ...	1	34.69	-	-	-	1.30	-	-	.80	-	-	1.54	-	-	-	-	2.45	1.13	-	-	-	-	41.33
Cotton waste, dry, ...	4	5.87	60.60	9.33	.96	1.77	1.76	.66	1.42	1.80	.26	.45	-	-	-	-	-	-	-	-	-	-	32.59
Refuse from calico works, ...	1	4.07	-	-	-	4.28	-	-	-	-	-	11.95	-	-	-	-	-	-	-	-	-	-	-
Cotton dust, ...	2	32.68	50.93	-	-	.78	-	-	.45	-	-	.32	-	-	-	-	-	-	-	-	-	-	42.22
Glucose refuse, ...	1	8.10	-	-	-	2.62	-	-	.15	-	-	.29	-	-	-	-	.18	.02	-	-	-	-	.07
Waste from lactate factory, . . .	1	34.11	-	-	-	.68	-	-	-	-	-	.67	-	-	-	-	22.59	-	-	-	-	-	6.92
Hop refuse, ...	1	8.98	-	-	-	.98	-	-	.11	-	-	.20	-	-	-	-	.27	.10	-	-	-	-	.63
Banana skins, ...	1	13.99	-	-	-	.24	-	-	5.46	-	-	1.80	-	-	-	-	-	-	-	-	-	-	-

	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
III. Refuse Substances — Concluded.																							
Tankage and blood,	1	14.43	-	-	-	5.88	-	-	-	-	-	6.84	5.44	1.08	.32	-	-	-	-	-	-	-	-
Sumac waste,	1	63.06	6.80	-	-	1.19	-	-	3.25	-	-	-	-	-	-	-	1.14	3.25	-	-	-	-	2.25
Eel grass,	2	35.30	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	-	-	-	1.63	2.13	.11	-	-	-	-	1.06
Pine-barren grass,	1	8.48	2.40	-	-	.16	-	-	.07	-	-	.18	-	-	-	-	-	-	-	-	-	-	1.67
Pine needles,	1	9.48	3.42	-	-	.46	-	-	.03	-	-	.12	-	-	-	-	-	-	-	-	-	-	1.22
Rockweed, green,	1	68.50	23.70	-	-	.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	1	10.68	35.75	-	-	1.45	-	-	4.89	-	-	2.75	-	-	-	7.90	7.60	.21	-	-	-	-	10.40
Jute waste,	1	13.10	-	-	-	1.50	-	-	.08	-	-	.72	-	-	-	-	-	-	-	-	-	-	-
Hair waste,	1	72.81	-	-	-	1.39	-	-	.32	-	-	.61	-	-	-	-	-	-	-	-	-	-	-
Starch waste from rubber factory,	1	10.01	.23	-	-	.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge from sewage precipitating tanks,	1	88.40	9.50	-	-	.05	-	-	.05	-	-	.10	-	-	-	-	1.58	.39	6.22	-	-	-	.93
Sludge,	1	6.28	-	-	-	.68	-	-	-	-	-	1.36	-	-	-	-	8.60	-	17.6[illegible]	-	-	-	38.03
Residue from water filter,	1	94.22	-	-	-	.12	-	-	-	-	-	.05	-	-	-	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*), dry,	1	16.26	-	-	-	4.25	-	-	.79	-	-	.19	-	-	-	3.53	2.06	1.18	-	-	-	-	5.53
Mussel mud, wet,	1	60.01	27.20	-	-	.21	-	-	6.17	-	-	.10	-	-	-	.70	.93	.14	3.48	-	-	-	-
Mussel mud, dry,	1	2.24	72.02	-	-	.72	-	-	-	-	-	.35	-	-	-	-	23.39	-	8.26	-	-	-	37.60

Madder,	2	11.93	-	-	-	.91	-	-	2.40	-	-	.35	-	-	-	-	3.93	.51	-	-	-	-	4.67
Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	-	-	-	-	-	-	.94	.91	.37	4.13	-	-	-	34.88
Fresh-water mud,	1	40.37	-	-	-	1.37	-	-	.22	-	-	.26	-	-	-	-	1.27	.29	1.80	-	-	-	18.26
Muck,	25	61.69	13.75	2.54	.12	.79	-	-	-	.17	.08	.13	-	-	-	-	-	-	-	-	-	-	10.68
Peat, wet,	11	61.36	7.66	1.40	.41	.85	-	-	.18	-	-	.09	-	-	-	-	.55	.72	2.14	-	-	-	2.14
Peat, dry,	2	14.67	17.26	-	-	1.89	-	-	.06	-	-	.03	-	-	-	-	-	-	-	-	-	-	10.14
Turf,	2	19.29	6.36	1.97	1.91	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soot,	7	4.29	77.10	1.05	.09	.41	1.83	.21	.63	2.10	.19	1.13	-	-	-	-	2.99	1.19	6.38	-	-	-	66.06
IV. Animal Excrement, etc.																							
Barn-yard manure,	79	67.24	-	1.36	.21	.52	1.40	.13	.56	.75	.10	.39	-	-	-	-	.30	.19	-	-	-	-	8.00
Horse manure,	1	11.24	-	-	-	.74	-	-	2.82	-	-	1.46	-	-	-	-	-	-	-	-	-	-	12.60
Sheep manure,	4	29.22	-	-	-	1.44	-	-	1.17	-	-	.92	-	-	-	-	-	-	-	-	-	-	12.91
Drainage from a manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	-	.95	-	-	-	-	-	-	-	-	-	-	-
Hen manure, fresh,	2	52.35	24.75	1.20	.79	.99	.32	.18	.25	1.00	.47	.74	-	-	-	-	1.19	.89	-	1.24	-	-	23.50
Hen-house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	-	1.02	-	-	-	-	-	-	-	-	-	-	71.07

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Alumina Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc.													
Muriate of potash,	35.	-	-	1,020.	-	134.	-	11.	-	-	-	976.	14.
Sulphate of potash (high grade),	37.	-	-	804.	-	89.	-	30.	-	914.	-	-	15.
Sulphate of potash-magnesia,	96.	-	-	496.	-	125.	51.	-	-	885.	-	52.	28.
Carbonate of potash,	538.	-	-	370.	-	-	-	390.	-	-	-*	-	8.
Phosphate of potash,	75.	-	-	651.	750.	-	-	-	-	269.	-	-	18.
Kainite,	64.	-	-	271.	-	379.	23.	196.	-	405.	-	665.	43.
Carnallite,	-	-	-	274.	-	153.	-	264.	-	11.	-	831.	-
Krugite,	96.	-	-	168.	-	105.	249.	176.	-	639.	-	133.	299.
Sulphate of magnesia (kieserite),	454.	-	-	-	-	-	56.	346.	-	722.	-	-	115.
Nitrate of potash,	26.	-	254.	905.	-	-	-	-	-	-	-	-	-
Nitrate of soda,	28.	-	301.	-	-	710.	-	-	-	-	-	10.	10.
Sulphate of ammonia,	212.	-	441.	-	-	-	-	-	-	1,200.	-	-	-
Phosphate of ammonia,	120.	-	207.	-	877.	-	-	-	-	249.	-	-	16.
Sulphate of soda,	28.	-	-	-	-	-	-	-	-	1,189.	-	-	-
Saltpetre waste,	51.	-	44.	273.2	-	740.8	15.	38.	-	37.	-	925.	-

Nitre salt-cake,	121.	-	56.	17.	-	591.	-	-	-	955.	-	-	78.
Wood ashes,	208.	-	-	108.	30.	-	671.	66.	19.	-	-	-	326.
Cotton-seed-hull ashes,	172.	-	-	451.	172.	-	188.	209.	35.	-	-	-	269.
Ashes of spent tan-bark,	97.	-	-	36.	37.	-	622.	68.	36.	-	-	-	504.
Corn-cob ashes,	24.	-	-	142.	47.	-	234.	-	26.	-	-	-	1,042.
Railroad-tie ashes,	91.	-	-	18.	11.	-	50.	-	-	-	-	-	1,604.
Peat ashes,	93.	-	-	9.	2.	-	46.	33.	123.	-	-	-	903.
Logwood ashes,	30.	-	-	2.	56.	-	78.	-	-	-	-	-	194.
Hard-pine wood ashes,	15.	-	-	203.	45.	-	499.	-	-	-	-	-	598.
Mill ashes,	11.	-	-	32.	9.	-	699.	27.	-	-	-	-	727.
Ashes from cremation of swill,	97.	-	-	79.	283.	-	672.	27.	93.	-	-	-	431.
Ashes from blue works,	243.	1,276.	-	180.	-	-	-	-	-	-	-	-	246.
Seaweed ashes,	29.	-	-	18.	6.	175.	121.	87.	-	60.	-	132.	1,273.
Gypse,	33.	-	-	-	-	-	1,017.	-	-	-	-	-	57.
Nova Scotia plaster (gypsum),	179.	-	-	-	-	-	657.	15.	-	897.	-	-	69.
Onondaga plaster (New York gypsum),	265.	-	-	-	-	-	606.	93.	-	650.	164.	-	187.
Lime (burnt),	-	-	-	-	-	-	1,973.	-	-	-	-	-	27.
Waste lime,	16.	-	-	-	-	-	1,482.	-	-	-	-	-	8.
Gas-house lime,	446.	-	-	-	-	-	873.	166.	-	415.	-	-	121.
Lime waste from sugar factory,	726.	-	-	4.	45.	-	550.	-	-	-	-	-	6.
Lime-kiln ashes,	290.	-	-	26.	22.	-	851.	52.	-	-	355.	-	154.
Bituminous coal ashes,	73.	-	-	8.	9.	-	38.	-	-	-	-	-	1,483.

* Not determined.

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc. — Concluded.													
Carbonate of lime,	9.	-	-	-	-	-	1,060.	-	-	-	-	-	-
Marls (Massachusetts),	274.	-	-	5.	21.	-	810.	13.	14.	-	571.	-	60.
Marls (Virginia),	320.	-	-	10.	2.	-	145.	4.	-	13.	145.	-	1,285.
Green sand marls (Virginia),	25.	-	-	23.	187.	-	516.	-	103.	-	-	-	826.
Olive earth (Virginia),	39.	-	-	5.	275.	-	383.	-	120.	-	-	-	1,011.
Ammoniated marl,	66.	-	32.	-	208.	-	-	-	-	-	-	-	-
Marl (North Carolina),	30.	-	-	1.	11.	-	439.	12.	-	-	-	-	1,004.
II. Guanos, Phosphates, etc.													
Peruvian guano,	296.	752.	157.	52.	305.	-	-	-	-	-	-	-	132.
Bat guano from Texas,	802.	365.	129.	26.	75.	-	-	-	-	-	-	-	40.
Bat guano from Florida,	313.	-	195.	25.	67.	-	-	-	-	-	-	-	387.
Rat guano from Florida,	206.	-	66.	137.	46.	-	-	-	-	-	-	-	23.
Cuban guano,	485.	-	33.	-	267.	-	-	-	-	-	-	-	63.
Caribbean guano (orchilla),	146.	-	-	-	535.	-	799.	66.	-	54.	-	-	25.
Mona Island guano,	266.	-	15.	-	438.	-	750.	-	-	-	-	-	49.

South Carolina rock phosphate,	27.	-	-	-	549.	-	837.	61.	96.	-	-	-	181.
South Carolina floats,	17.	-	-	-	468.	-	-	-	-	-	-	-	403.
Florida rock phosphate,	40.	-	-	4.	520.	-	608.	-	154.	-	22.	-	546.
Soft Florida phosphate,	97.	-	-	-	375.	-	274.	-	136.	-	-	-	418.
Navassa phosphate,	152.	-	-	-	685.	-	749.	-	205.	-	-	-	54.
Brockville phosphate,	50.	-	-	-	704.	-	-	-	-	-	-	-	129.
Phosphatic slag,	29.	-	-	-	470.	-	973.	68.	202.	-	-	-	188.
Odorless phosphate,	60.	-	-	8.	391.	-	1,028.	-	-	-	50.	-	183.
Dissolved bone-black,	203.	950.	-	-	325.	-	-	-	-	-	-	-	80.
Upton phosphate,	181.	-	-	-	803.	-	-	-	-	-	-	-	-
Bone-black,	92.	-	-	-	565.	-	-	-	-	-	-	-	73.
Double superphosphate,	115.	-	-	-	956.	-	320.	-	-	24.	-	-	12.
South American bone ash,	140.	-	-	-	718.	-	898.	-	-	-	-	-	90.
Acid phosphate,	285.	1,399.	-	-	293.	-	-	-	-	-	-	-	216.
III. Refuse Substances.													
Dried blood,	229.	127.	209.	-	53.	-	-	-	-	-	-	-	-
Ammonite,	118.	-	227.	-	69.	-	-	-	-	-	-	-	28.
Oleomargarine refuse,	171.	288.	242.	-	18.	-	-	-	-	-	-	-	19.
Felt refuse,	585.	671.	105.	-	-	-	-	-	-	-	-	-	-
Sponge refuse,	145.	-	49.	-	64.	-	79.	25.	-	-	-	-	781.
Blood and bone,	167.	-	135.	-	220.	-	-	-	-	-	-	-	-
Horn shavings,	99.	-	306.	-	8.	-	-	-	-	-	-	-	-

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Continued.													
Ivory dust,	230.	1,053.	133.	-	491.	-	-	-	-	-	-	-	-
Horn and hoof waste,	203.	153.	265.	-	37.	-	-	-	-	-	-	-	5.
Raw wool,	139.	151.	258.	-	-	-	-	-	-	-	-	-	72.
Wool waste,	235.	582.	91.	34.	6.	-	2.	1.	16.	-	-	-	164.
Wool washings (water),	-	-	-	78.	-	10.	6.	-	-	-	-	-	-
Wool washings (acid),	-	-	-	84.	-	8.	12.	4.	-	-	-	-	-
Wool washings (alkaline),	1,841.	66.	2.	22.	-	18.	1.	-	-	-	-	-	4.
Morocco factory waste,	454.	-	23.	7.	51.	-	392.	-	-	25.	-	-	483.
Meat scrap,	496.	-	127.	-	116.	-	-	-	-	-	-	-	-
Meat mass,	242.	272.	209.	-	41.	-	-	-	-	-	-	-	12.
Bone soup,	1,658.	141.	23.	-	25.	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	296.	168.	199.	-	11.	-	-	-	-	-	-	-	13.
Dried soup from rendering cattle feet,	216.	150.	289.	-	9.	-	-	-	-	-	-	-	5.
Dried soup from horse rendering,	1,843.	-	22.	-	3.	-	-	-	-	-	-	-	-
Soap grease refuse,	585.	1,028.	64.	-	264.	-	-	-	-	-	-	-	26.

Ground bones,	135.	1,061.	77.	-	449.	-	-	-	-	-	-	-	22.
Meat and bone,	105.	-	91.	-	404.	-	-	-	-	-	-	-	24.
Tankage,	164.	-	123.	-	257.	-	-	-	-	-	-	-	-
Fish with less than twenty per cent. water,	244.	430.	152.	-	170.	-	-	-	-	-	-	-	40.
Fish with between twenty and forty per cent. water,	604.	412.	119.	-	142.	-	-	-	-	-	-	-	34.
Fish with more than forty per cent. water,	909.	310.	99.	-	102.	-	-	-	-	-	-	-	27.
Whale meat, raw,	890.	21.	96.	-	-	-	-	-	-	-	-	-	-
Lobster shells,	145.	-	90.	-	70.	-	445.	26.	-	-	-	-	5.
Castor-bean pomace,	194.	114.	110.	31.	44.	-	17.	6.	-	-	-	-	35.
Cotton-seed meal,	141.	116.	132.	35.	36.	-	-	-	-	-	-	-	6.
Linseed meal,	169.	-	127.	25.	37.	-	-	-	-	-	-	-	-
Rotten brewers' grain,	1,575.	-	15.	1.	17.	-	5.	3.	-	-	-	-	12.
Mill sweepings,	190.	-	75.	13.	24.	-	-	-	-	-	-	-	100.
Tobacco leaf,	261.	420.	55.	145.	9.	-	83.	43.	6.	-	-	-	83.
Tobacco stems,	212.	281.	46.	141.	12.	7.	78.	25.	-	-	-	-	16.
Cotton waste, wet,	694.	-	26.	16.	31.	-	49.	23.	-	-	-	-	827.
Cotton waste, dry,	117.	1,212.	35.	28.	9.	-	-	-	-	-	-	-	652.
Refuse from calico works,	81.	-	86.	-	239.	-	-	-	-	-	-	-	-
Cotton dust,	654.	1,019.	16.	9.	6.	-	-	-	-	-	-	-	844.
Glucose refuse,	162.	-	52.	3.	6.	-	4.	4.	-	-	-	-	1.
Waste from lactate factory,	682.	-	14.	-	13.	-	452.	-	-	-	-	-	138.
Hop refuse,	180.	-	20.	2.	4.	-	5.	2.	-	-	-	-	13.

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Concluded.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Concluded.													
Banana skins,	280.	-	5.	109.	36.	-	-	-	-	-	-	-	-
Tankage and blood,	289.	-	118.	-	137.	-	-	-	-	-	-	-	-
Sumac waste,	1,261.	136.	24.	65.	-	-	23.	65.	-	-	-	-	45.
Eel grass,	708.	312.	17.	18.	6.	33.	43.	2.	-	-	-	-	21.
Pine-barren grass,	170.	48.	3.	1.	4.	-	-	-	-	-	-	-	33.
Pine needles,	200.	68.	9.	1.	2.	-	-	-	-	-	-	-	24.
Rockweed, green,	1,370.	474.	12.	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	214.	715.	29.	98.	55.	158.	153.	4.	-	-	-	-	208.
Jute waste,	262.	-	3.	2.	14.	-	-	-	-	-	-	-	-
Hair waste,	1,456.	-	28.	6.	12.	-	-	-	-	-	-	-	-
Starch waste from rubber factory,	200.	5.	4.	-	-	-	-	-	-	-	-	-	-
Sludge from sewage precipitating tanks,	1,770.	190.	1.	1.	2.	-	32.	8.	124.	-	-	-	19.
Sludge,	126.	-	14.	-	27.	-	173.	-	354.	-	-	-	761.
Residue from water filter,	1,884.	-	2.	-	1.	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*), dry,	325.	-	85.	16.	4.	71.	41.	24.	-	-	-	-	111.

Mussel mud, wet,	1,200.	546.	4.	123.	2.	14.	19.	3.	70.	-	-	-	-
Mussel mud, dry,	45.	1,440.	14.	-	7.	-	1,468.	165.	-	-	-	-	752.
Madder,	239.	-	18.	48.	7.	-	79.	10.	-	-	-	-	93.
Salt mud,	1,567.	824.	8.	7.	-	19.	18.	7.	83.	-	-	-	798.
Fresh-water mud,	807.	-	27.	4.	5.	-	25.	6.	36.	-	-	-	365.
Muck,	1,234.	275.	16.	-	3.	-	-	-	-	-	-	-	214.
Peat, wet,	1,227.	153.	17.	4.	2.	-	11.	14.	43.	-	-	-	43.
Peat, dry,	293.	345.	38.	1.	1.	-	-	-	-	-	-	-	203.
Turf,	386.	127.	39.	-	-	-	-	-	-	-	-	-	-
Soot,	86.	1,542.	8.	13.	23.	-	60.	24.	128.	-	-	-	1,321.
IV. Animal Excrement, etc.													
Barn-yard manure,	1,345.	-	10.	11.	8.	-	6.	4.	-	-	-	-	160.
Horse manure,	225.	-	15.	56.	29.	-	-	-	-	-	-	-	252.
Sheep manure,	584.	-	29.	23.	18.	-	-	-	-	-	-	-	258.
Drainage from manure heap,	1,864.	73.	20.	18.	5.	-	-	-	-	-	-	-	-
Poudrette, dry,	105.	709.	72.	10.	115.	-	-	-	-	-	-	-	93.
Goose manure,	978.	-	4.	16.	19.	-	-	-	-	-	-	-	-
Hen manure, fresh,	1,047.	49.	20.	5.	15.	-	24.	18.	-	25.	-	-	470.
Hen house refuse,	147.	-	14.	21.	20.	-	-	-	-	-	-	-	1,421.

5. Compilation of Analyses of Fruits, Garden Crops and Insecticides.

COMPILED BY H. D. HASKINS.

1. — Analyses of fruits.

2. — Analyses of garden crops.

3. — Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops.

4. — Analyses of insecticides.

A computation of the results of a chemical analysis of twenty prominent garden crops shows the following average relative proportion of the three essential ingredients of plant food: —

	Parts.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain, on the above-stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weight and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limit pays, as a rule, better than a scanty one. — (C. A. Goessmann.)

1. *Analyses of Fruits.*

Fertilizing Constituents of Fruits.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Ericaceæ: —										
*Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
*Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
*Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
*Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
*Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–
*Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Saxifragaceæ: —										
*Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
*Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	–	–
Vitaceæ: —										
Grapes,	830	1.7	8.8	5.0	.1	1.0	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

2. *Analyses of Garden Crops.*

Fertilizing Constituents of Garden Crops.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ:—										
Mangolds,	880	1.8	9.1	4.8	1.5	.3	.4	.8	.3	.9
*Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–
Mangold leaves,	905	3.0	14.6	4.5	2.8	1.6	1.4	1.0	.8	2.3
Sugar beets,	805	1.6	7.1	3.8	.6	.4	.6	.9	.3	.3
*Sugar beets,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Sugar-beet tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Sugar-beet leaves,	897	3.0	15.3	4.0	2.0	3.1	1.7	.7	.8	1.3
Sugar-beet seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9
*Red beets,	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–
Spinach,	903	2.4	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
*Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositeæ:—										
Lettuce, common,	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Head lettuce,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	.4	.8
*Head lettuce,	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Roman lettuce,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4
Artichoke,	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
*Artichoke, Jerusalem,	775	4.6	–	4.8	–	–	–	1.7	–	–
Convolvulaceæ:—										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ:—										
White turnips,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
*White turnips,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
White turnip leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2
*Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Savoy cabbage,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
White cabbage,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
*White cabbage,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3

Fertilizing Constituents of Garden Crops — Continued.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Cruciferæ — Concluded.										
Radishes, ...	933	1.9	4.9	1.6	1.0	.7	.2	4.5	.3	.5
Kohlrabi, ...	850	4.8	12.3	4.3	.8	.4	.8	2.7	1.1	.6
Cucurbitaceæ: —										
Cucumbers, ...	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins, ...	900	1.1	4.4	.9	.9	.3	.2	.7	.3	.4
Gramineæ: —										
Corn, whole plant, green, .	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5
*Corn, whole plant, green, .	786	4.1	–	3.8	.5	1.5	.9	1.5	–	–
Corn kernels, ...	144	16.0	12.4	3.7	.1	.3	1.9	5.7	.1	.2
*Corn kernels, ...	100	18.2	–	4.0	.3	.3	2.1	7.0	–	–
*Corn, whole ears, . . .	90	14.1	–	4.7	.6	.2	1.8	5.7	–	–
*Corn stover, ...	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	–	–
Leguminosæ: —										
Hay of peas, cut green, . .	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
*Cow-pea (*Dolichos*), green, .	788	2.9	–	3.1	.6	3.0	1.0	1.0	–	–
*Small pea (*Lathyrus sylvestris*), dry.	90	38.5	–	25.7	4.7	17.9	5.0	9.0	–	–
Peas (seed), ...	143	35.8	23.4	10.1	.2	1.1	1.9	8.4	.8	.4
Pea straw, ...	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Garden beans (seed), . .	150	39.0	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Bean straw, ...	166	–	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
Liliaceæ: —										
Asparagus, ...	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
Onions, ...	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
*Onions, ...	892	–	4.9	1.8	.1	.4	.2	.7	–	–
Solanaceæ: —										
Potatoes, ...	750	3.4	9.5	5.8	.3	.3	.5	1.6	.6	.3
*Potatoes, ...	798	2.1	9.9	2.9	.1	.1	.2	.7	–	–
Potato tops, nearly ripe, . .	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe, . . .	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
*Tomatoes, ...	940	1.7	–	3.6	–	.3	.2	.4	–	–
Tobacco leaves, ...	180	34.8	140.7	40.7	4.5	50.7	10.4	6.6	8.5	9.4
Tobacco stalks, ...	180	24.6	64.7	28.2	6.6	12.4	.5	9.2	2.2	2.4
*Tobacco stems, ...	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	–	–

Fertilizing Constituents of Garden Crops — Concluded.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Umbelliferæ: —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.5	.4
*Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	–	–
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	–	–
Parsnips,	793	5.4	10.0	.4	.2	1.1	.6	1.9	.5	.4
*Parsnips,	803	2.2	–	6.2	.1	.9	.5	1.9	–	–
Celery,	841	2.4	17.6	7.6	–	2.3	1.0	2.2	1.0	2.8

Most of the foregoing analyses were compiled from the tables of E. Wolff. Those marked * are from analyses made at the Massachusetts State Agricultural Experiment Station, Amherst, Mass.

3. *Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Ericaceæ: —			
*Cranberries,	1	3.0	–
*Cranberries,	1	3.4	2.6
Rosaceæ: —			
Apples,	1	2.7	2.0
*Apples,	1	1.9	1.3
*Peaches,	1	1.3	–
Pears,	1	3.6	1.2
Strawberries,	1	1.4	–
*Strawberries,	1	2.6	–
*Strawberry vines,	1	.7	–
Cherries,	1	3.3	–
Plums,	1	4.3	–
Saxifragaceæ: —			
*Currants, white,	1	2.8	–
*Currants, red,	1	2.1	–
Gooseberries,	1	1.9	–
Vitaceæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7

Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Chenopodiaceæ: —			
Mangolds,	1	6.0	2.3
*Mangolds,	1	4.2	2.1
Mangold leaves,	1	4.5	3.0
Sugar beets,	1	4.2	1.8
*Sugar beets,	1	4.8	2.2
Sugar-beet tops,	1	2.3	1.7
Sugar-beet leaves,	1	5.7	4.3
Sugar-beet seed,	1	1.5	–
*Red beets,	1	4.1	3.3
Spinach,	1	1.7	3.1
*Spinach,	1	19.2	6.8
Compositeæ: —			
Lettuce,	1	5.3	–
*Lettuce,	1	7.6	4.0
Head lettuce,	1	3.9	2.2
Roman lettuce,	1	2.3	1.8
*Jerusalem artichoke,	1	2.8	2.7
Convolvulaceæ: —			
Sweet potato,	1	4.6	3.0
Cruciferæ: —			
White turnips,	1	3.6	2.3
*White turnips,	1	3.9	1.8
White turnip leaves,	1	3.1	3.3
*Ruta-bagas,	1	4.1	1.6
Savoy cabbage,	1	1.9	2.5
White cabbage,	1	4.1	1.7
*White cabbage,	1	11.0	7.6
Cauliflower,	1	2.3	2.5
Horse-radish,	1	3.9	2.2
Radishes,	1	3.2	3.8
Kohlrabi,	1	1.6	1.8
Cucurbitaceæ: —			
Cucumbers,	1	2.0	1.3
Pumpkins,	1	.6	.7
Gramineæ: —			
Corn, whole plant, green,	1	3.7	1.9
*Corn, whole plant, green,	1	2.2	2.8
Corn kernels,	1	.6	2.8
*Corn kernels,	1	.6	2.6
*Corn, whole ears,	1	.8	2.5
*Corn stover,	1	4.4	3.7

Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Garden Crops — Concluded.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Leguminosæ : —			
Hay of peas, cut green,	1	3.4	3.4
*Cow-pea (*Dolichos*),	1	3.1	2.9
*Small pea (*Lathyrus sylvestris*),	1	3.4	4.2
Peas (seed),	1	1.2	4.3
Pea straw,	1	2.8	4.0
Garden beans (seed),	1	1.2	4.0
Bean straw,	1	3.3	–
Liliaceæ : —			
Asparagus,	1	1.3	3.6
Onions,	1	1.9	2.1
*Onions,	1	2.6	–
Solanaceæ : —			
Potatoes,	1	3.6	2.1
*Potatoes,	1	4.1	3.0
Potato tops, nearly ripe,	1	2.7	3.1
Potato tops, unripe,	1	3.7	5.3
*Tomatoes,	1	8.7	4.5
Tobacco leaves,	1	6.2	5.3
Tobacco stalks,	1	3.1	2.7
Tobacco stems,	1	10.7	3.8
Umbelliferæ : —			
Carrots,	1	2.7	2.0
*Carrots,	1	5.7	1.7
Carrot tops,	1	2.9	5.1
*Carrot tops, dry,	1	8.0	5.1
Parsnips,	1	3.8	2.8
*Parsnips,	1	3.3	1.2
Celery,	1	3.5	1.1

6. *Analyses of Insecticides.*

	Moisture.	Arsenious Oxide.	Copper Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Matter Insoluble in Hydrochloric Acid.
Average of 12 analyses, ordinary Paris Green,	1.22	57.91	32.08	4.74	-	-	-	-	-	-	-	-	.20
Average of 4 analyses, "Lion Brand New-process Paris Green,"	4.64	54.91	7.93	-	-	-	-	6.65	-	15.76	.35	-	1.00
"Sulphatine,"	1.40	-	2.61	-	-	-	48.28	4.73	-	18.60	-	-	1.63
"Death to Rose Bugs,"	2.95	-	1.05	-	-	-	34.53	4.35	-	17.76	-	-	.49
"Professor De Graff's Carpet Bug Destroyer,"	95.81	-	-	-	-	.78	-	.48	.27	-	.26	.90	-
"Oriental Fertilizer and Bug Destroyer,"	87.14	2.38	-	-	-	-	-	.64	3.00	-	3.50	-	-
"Non-poisonous Potato Bug Destroyer,"	-	-	-	-	-	-	-	-	-	68.20	-	1.38	1.50
Tobacco liquor,	37.71	-	-	-	2.12	-	-	-	-	3.07	6.55	.23	-
Tobacco liquor,	40.89	-	-	-	.53	-	-	-	-	1.47	16.34	.01	-
Tobacco liquor,	-	-	-	-	4.55	-	-	-	-	-	-	-	-
Tobacco liquor,	-	-	-	-	4.82	-	-	-	-	-	-	-	-
"Nicotinia,"	10.00	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	2.34
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	38.12
"Peroxide of Silicate,"	1.65	.57	.33	-	-	-	-	49.66	-	41.18	-	-	2.31

As a rule, in all preceding analyses the essential constituents are determined and stated; blanks do not imply the absence of the non-essentials.

INDEX.

PUBLIC DOCUMENT . . . . No. 33.

TENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1898.

BOSTON:
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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
George D. Leavens, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, B.Sc.,	*Assistant Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
G. A. Drew, B. Sc.,	*Assistant Horticulturist.*
H. D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
H. H. Roper, B.Sc.,	*Assistant in Foods and Feeding.*
A. C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 28. Canker, army and corn worms; red-humped apple-tree caterpillar; antiopa butterfly; currant stem girdler; imported elm-bark louse; greenhouse orthezia.
No. 29. Fungicides and insecticides; new spraying pump; spraying calendar.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 36. Imported elm-leaf beetle; maple pseudococcus; abbot sphinx; San José scale.
No. 37. Report on fruits, insecticides and fungicides.
No. 38. Fertilizer analyses; composition of Paris green; action of muriate of potash on the lime resources of the soil.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 44. Variety tests of fruits; tests of vegetable seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can only be supplied to complete sets for libraries.

The work during the year has been unusually diversified in its character and importance, a result of the numerous problems sent in for solution. In the agricultural division, soil tests with corn and potatoes grown in several localities have been continued; a comparison of different fertilizers

has been made; "Nitragin" has again been tried, with negative results; and an interesting test has been carried on of twenty varieties of corn, eighty-one of potatoes, sixty of grasses, twenty-one of millets and four of clover.

In the division of chemistry (fertilizers), aside from the six hundred analyses of licensed fertilizers and manurial substances, valuable work has been done for the tobacco-growers of the Connecticut valley in the analyses of tobacco leaves grown with different fertilizers, testing of the quality of ash and burning quality, and suggestions as to methods of planting, fertilizers to be employed and mechanical preparation of the soil.

In the botanical division, investigations have been carried on of the brown rot of stone fruit, the chrysanthemum rust, the leaf blights of certain native trees, as the sycamore, butternut, chestnut and black cherry, with recommendations of treatment for the brown rot and chrysanthemum rust.

The horticultural division has continued its work of testing varieties of fruit and seeds of vegetables, and has entered upon an investigation of the use of hydrocyanic acid as an insecticide.

From the entomological division have issued two important bulletins on the habits, food and economic value of the American toad and the brown-tail moth. A monograph on the plume-moths (some varieties of which attack plants of economic value and those raised for ornamental purposes) has been completed. The superiority of spraying for the canker worm over ink bands and oil troughs has been demonstrated, and investigations carried on of new insecticides with which to assail the gypsy moth.

A series of observations for the electrical determination of moisture in the soil, in connection with the growth of corn, were undertaken by the meteorological division. Owing to breaks in the circuit and other causes that made the instrument fail to work, and the abnormally wet weather of the summer, the results were not entirely satisfactory, and the observations will be repeated the coming season.

Three investigations in the division of foods and feeding are worthy of special note: (*a*) On the comparative values

of corn meal and hominy and cerealine feeds for pork production, when fed in combination with skim-milk. It was found that the pigs did quite as well on these feeds as on an equal amount of corn meal. (*b*) On salt-marsh hay. It was found to possess less feeding value than English hay, but, combined with grain and ensilage, produced nearly as much milk and butter as an equal amount of English hay thus combined. (*c*) On cotton-seed feed as a hay substitute for milch cows. More energy was used up in its digestion than in hay, and it was concluded that Massachusetts farmers would derive no benefit from feeding this material in place of hay.

Reports of the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1897.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,087 75	
for labor,	3,312 26	
for publications,	2,354 06	
for postage and stationery,	264 11	
for freight and express,	245 78	
for heat, light and water,	193 31	
for seeds, plants and sundry supplies,	600 55	
for feeding stuffs,	185 11	
for library,	1,139 85	
for tools, implements and machinery,	272 21	
for furniture and fixtures,	33 43	
for scientific apparatus,	226 83	
for live stock,	125 45	
for travelling expenses,	352 32	
for contingent expenses,	42 73	
for building and repairs,	564 25	
		$15,000 00

Cash on hand July 1, 1896,	$1,042 92	
Received from State treasurer,	10,000 00	
from fertilizer fees,	4,087 75	
from farm products,	1,934 15	
from miscellaneous sources,	1,022 19	
		$18,087 01
Cash paid for salaries,	$10,784 83	
for labor,	1,075 81	
for publications,	175 03	
for postage and stationery,	156 18	
for freight and express,	187 48	
for heat, light and water,	361 64	
Amount carried forward,	$12,740 97	

Amount brought forward,	$12,740 97	
Cash paid for chemical supplies,	592 48	
for seeds, plants and sundry supplies,	515 54	
for fertilizers,	1,074 41	
for feeding stuffs,	559 24	
for library,	61 82	
for tools, implements and machinery,	28 62	
for furniture and fixtures,	176 12	
for scientific apparatus,	357 48	
for live stock,	359 45	
for travelling expenses,	72 72	
for contingent expenses,	273 03	
for building and repairs,	1,255 40	
Cash on hand June 30, 1897,	19 73	
		$18,087 01

AMHERST, MASS., Aug. 30, 1897.

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1897; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,087.01, and the corresponding disbursements $33,067.28. All the proper vouchers are on file and have been by me examined and found to be correct, there being a balance of $19.73 on accounts of the fiscal year ending June 30, 1897.

CHARLES A. GLEASON,
Auditor.

REPORT OF THE AGRICULTURIST.

WILLIAM P. BROOKS.

Soil Tests.

Four soil tests upon the plan heretofore followed were attempted during the past year; viz., with corn in Norwell and Montague, with potatoes and with onions (and later cabbages) upon our home grounds. Only the tests in Norwell and with potatoes upon our home grounds were successfully carried through.

Unfavorable weather conditions destroyed the onions and cabbages upon our south soil-test acre. The field was sown to white mustard late in July. But four plots furnished sufficient growth to cut and weigh; viz., lime plot, 1 pound; manure plot, 425 pounds; nitrate and dissolved bone-black, 45 pounds; potash and dissolved bone-black, 25 pounds; nitrate, dissolved bone-black and potash plot, 255 pounds,— all green weights.

The field has now been used nine years in soil-test work, and we have a high degree of one-sided exhaustion on most of the plots. The close dependence of the mustard upon a supply of phosphoric acid (furnished by the bone-black) is brought out, as was the case in 1895; but phosphoric acid alone can no longer produce any growth of mustard upon this soil. The addition of either nitrogen or potash helps it, the former most; but not much growth is produced unless all three are supplied.

The soil test with corn in Montague was ruined by wire and cut worms. As nearly as could be determined from the portion of the crop left, nitrogen seemed the most necessary element upon this soil.

1. *Soil Test with Corn. Norwell.*

This is the second year of soil-test work in this field, the crop last year also being corn. Last year potash was the controlling element; the result this year is the same. Muriate of potash, at the rate of 160 pounds per acre, gives an average increase at the rate of 36.3 bushels of grain and 2,203 pounds of stover; nitrate of soda, at the same rate per acre, gives an average increase of 8.3 bushels of grain and 325 pounds of stover; dissolved bone-black, at the rate of 320 pounds per acre, gives an average increase of 15.3 bushels of grain and 455 pounds of stover. Five cords of manure increase the crop by 26.4 bushels of grain and 3,450 pounds of stover per acre; complete fertilizer (nitrate, dissolved bone-black and potash at above rates) gives an increase of grain 52.5 bushels and stover 2,455 pounds; lime and plaster both produce apparent small increases.

2. *Soil Test with Potatoes. Amherst.*

The field upon which this test was carried out lies upon our own grounds. It has a medium, well-drained loam, and has been seven years in soil-test experiments. The crops in order of succession have been potatoes, corn, soya beans, oats, grass and clover (two years), and cabbages and Swedish turnips. This year the phosphoric acid gives the largest average increase in crop, viz., at the rate of 26.6 bushels of merchantable tubers per acre; nitrogen gives an increase of 11.3 bushels merchantable tubers and potash an increase of 7.2 bushels. The soil, however, is very generally exhausted, and no single fertilizer or combination of either two or all three gave a good crop. The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which those two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion

that the nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must therefore conclude that some disturbing factor, at present unknown, influenced the results; and we are, therefore, unable to draw practical conclusions which throw light upon the proper practice to be followed in manuring the potato crop.

Manure Alone v. Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a small application of manure used in connection with muriate of potash was begun in 1890. A full account of the results will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn in July of last year. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash has been used this year. The field includes four plots of one-fourth of an acre each. The results for 1897 are shown below: —

Plot 1 (1½ cords of manure alone, 1890–96): hay, 1,420 pounds; rowen, 783 pounds.

Plot 2 (1 cord manure and 40 pounds of muriate of potash, 1890–96): hay, 885 pounds; rowen, 483 pounds.

Plot 3 (manure alone, as for Plot 1): hay, 1,380 pounds; rowen, 785 pounds.

Plot 4 (manure and potash, as for Plot 2): hay, 1,037½ pounds; rowen, 590 pounds.

The averages are as follows: —

Plots 1 and 3 (manure alone, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure and potash, 1890–96): hay, 961¼ pounds; rowen, 536½ pounds.

Combining the figures showing the averages of hay and rowen, we find that plots 1 and 3 have produced an average of 2,187 pounds per plot, which is at the rate of 4 tons, 748 pounds, per acre. Plots 2 and 4 have produced an average of 1,497¼ pounds per plot, which is at the rate of 9 pounds less than 3 tons per acre. The larger quantity of manure, then, produced this year about 1⅓ tons more per acre than the manure and potash. This is a large difference, but a difference which was to be anticipated, in view of the much larger quantity of plant food which has been applied to these plots. It remains to be seen whether the clover on plots 2 and 4 will be capable of so enriching the soil in nitrogen as to remove or lessen this difference in succeeding years.

"Special" Corn Fertilizer v. Fertilizer richer in Potash.

This experiment was begun with a view of comparing the results obtained with a fertilizer proportioned like the average of the "*special*" *corn fertilizers* found upon our markets in 1891 with those obtained with a fertilizer richer in potash but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots, of one-fourth of an acre each. The materials applied to the several plots are shown in the following table: —

FERTILIZERS.	Plots 1 and 3 (Pounds each).	Plots 2 and 4 (Pounds each).
Nitrate of soda,	20	18
Dried blood,	30	30
Dry ground fish,	30	20
Plain superphosphate,	226	120
Muriate of potash,	22.5	60
Cost of materials per plot,	$3 23	$3 10

Fertilizers were applied evenly broadcast on April 11. The yields the past year are shown below: —

Plot 1, "special" fertilizer: hay, 795 pounds; rowen, 130 pounds.

Plot 2, fertilizer richer in potash: hay, 810 pounds; rowen, 129 pounds.

Plot 3, "special" fertilizer: hay, 725 pounds; rowen, 97 pounds.

Plot 4, fertilizer richer in potash: hay, 617 pounds; rowen, 165 pounds.

The average yield on plots 1 and 3 is: hay, 760 pounds; rowen, 113½ pounds. On plots 2 and 4: hay, 713½; rowen, 147 pounds. Putting the crops of hay and rowen together, we have an average from 1 and 3 of 873½ pounds, and from 2 and 4 of 860½ pounds. The difference, 13 pounds, is too small to be regarded as of much significance. The greater rowen crop produced by plots 2 and 4 is perhaps to be attributed to the larger amount of potash which has been applied to these plots, which favors especially the growth of the clovers. Inequality of moisture conditions, however, has been the apparent cause of a very uneven development of clover on different parts of the field, and the influence of the potash does not show as clearly as was anticipated.

Natural Phosphates compared with Each Other and with Acid Phosphate. (Field F.)

This series of experiments was begun by Dr. Goessmann in 1890, with a view of determining whether it is not more profitable to employ one of the cheaper natural phosphates than to use the more costly acid phosphate. A full account of the experiment and the results obtained up to the end of 1896 is given by Dr. Goessmann in our ninth annual report. It is only necessary to restate the following points: —

The field was at first divided into five plots, containing about 6,600 square feet each. These plots received equal money's worth (on the basis of prices in 1890) of the phosphates used, as follows: Plot 1, phosphatic slag; Plot 2, Mona guano; Plot 3, at first, apatite; later, Florida phosphate; Plot 4, South Carolina phosphate; Plot 5, dissolved bone-black. Plot 3, as above stated, received an application of ground apatite in 1890. In 1891 it was found impossible to obtain this material, and no phosphate of any kind was applied to this plot. In 1892 and 1893 ground hard Florida phosphate was applied to this plot. It is not believed, however, that it is fair to this phosphate to compare it with the others, since it has been used only two years, while the others have been applied for four years.

From the beginning, each of these five plots has received the same application of nitrate of soda and potash-magnesia sulphate. The quantities of these applied per plot during the first four years were about 44 pounds of the former and 66 pounds of the latter.*

Since 1894 no phosphate of any kind has been applied to these plots, but the quantity of nitrate of soda and of potash-magnesia sulphate has been used in one-half greater quantities.

At first Dr. Goessmann included no plot on which phosphate was not used for comparison with others. Later such a plot was added, but it was left entirely unmanured until 1896. During 1896 and 1897 it has received the nitrate of

* The plots in this experiment differ from each other by a few square feet in size, and the fertilizers have from the beginning varied in proportion as the size varied.

soda and potash-magnesia sulphate at the same rate as the other plots.

The yield of the plots receiving phosphate for each of the years 1890–96 inclusive will be found in our ninth annual report. This report also contains a statement showing the amounts of phosphoric acid applied and removed from each plot during each of these years. This statement shows an excess added over and above that removed from each of the plots at the end of the season of 1896 as follows: where phosphatic slag had been used, the amount of phosphoric acid remaining was 65.6 pounds; where Mona guano had been used, 44.2 pounds; where apatite and Florida phosphate had been used, 141.7 pounds; where South Carolina rock phosphate had been used, 115.0 pounds; and where acid phosphate had been used, 21.8 pounds.

The crop during the past year was Swedish turnips. The field had been sown with rye for winter protection in the fall of 1896. The growth of the rye was characterized as poor. It was ploughed on June 1, the land was harrowed on the 2d, and on the 3d of June, Laing's Swedes were sown in drills two feet apart. The seed germinated promptly and evenly, but the season was much too wet for the best growth of the crop. It was, however, kept free from weeds by frequent cultivation. The crop was thinned on June 20 to eight inches. It was harvested November 2–4. The turnips were poor in quality, small, and a few of them decayed.

The yields of the several plots were as follows: —

	Roots (Pounds).	Tops (Pounds).
Plot 0, no phosphate,	830	185
Plot 1, phosphatic slag,	1,870	480
Plot 2, Mona guano,	3,655	800
Plot 3, Florida hard phosphate,	820	400
Plot 4, South Carolina rock phosphate,	1,965	560
Plot 5, dissolved bone-black,	1,619	370

It will be noticed that the crop on the phosphatic slag, Mona guano and South Carolina rock surpasses that where dissolved bone-black was used, and that the Mona guano gives nearly twice the product obtained by either the slag or the South Carolina rock. It will be further noticed that the Florida phosphate yields practically the same amount of roots as the plot receiving no phosphate. None of the crops secured this year can be regarded as good. The largest yield, that on the Mona guano plot, is at the rate of rather less than 12 tons per acre. A good crop should be about 20 tons per acre. The results of this year, therefore, although showing marked differences, are not regarded as decisive. The peculiarities of the season produced an unhealthy condition, which interfered with the full action of the fertilizers employed.

Comparison of Different Phosphates.

The results of the experiments inaugurated by Dr. Goessmann for the comparison of different phosphates with acid phosphate having proved so interesting and valuable, it was decided to inaugurate another series of experiments, including a greater number of materials supplying phosphoric acid. It was further thought best to apply these materials upon the basis of equal quantities of phosphoric acid to each plot, rather than on the basis of equal money's worth, as in the experiments planned by Dr. Goessmann.

The land selected for the experiment was fairly level, with a medium heavy loam. It had been in grass for many years. In April, 1896, it received an application of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. The season was very dry, and the grass derived little benefit from the fertilizers. The grass was cut about the middle of June, and the field was ploughed on June 24 and 25, 1896, and planted to Longfellow corn. The corn was cut when in the milk, September 26, and weighed as put into the silo. The field had been divided into 13 plots, of one-eighth of an acre each, separated by suitable unmanured strips. The yields of corn in 1896 were as follows: —

Plot 1, 2,640 pounds; Plot 2, 2,990 pounds; Plot 3, 2,915 pounds; Plot 4, 3,555 pounds; Plot 5, 2,885 pounds; Plot 6, 2,905 pounds; Plot 7, 2,850 pounds; Plot 8, 3,020 pounds; Plot 9, 3,160 pounds; Plot 10, 3,095 pounds; Plot 11, 3,000 pounds; Plot 12, 3,090 pounds; Plot 13, 3,440 pounds.

These weights were taken with a view to determining whether these plots were fairly even in fertility. It will be noticed that with three exceptions, plots 1, 4 and 13, this appears to be the case. Plot 1 is apparently poorer than the average, while plots 4 and 13 are better.

In 1897 the soil was thoroughly prepared by the use of the wheel harrow. Fertilizers were applied May 11. Each plot in the field received the following materials: potash-magnesia sulphate, 50 pounds; nitrate of soda, $30\frac{1}{4}$ pounds; sulphate of potash, high grade, $12\frac{1}{2}$ pounds. These materials supplied the potash and nearly all the nitrogen estimated to be required. Some of the phosphates to be employed (the bone meals), however, contained nitrogen as well as phosphoric acid, and, to equalize conditions on all the plots, sufficient hoof meal was applied to those not receiving bone to make the quantity of nitrogen applied to each plot throughout the field the same.

The plots contained, as stated, one-eighth of an acre each, and the materials used furnished to each plot phosphoric acid, 12 pounds; nitrogen, $6\frac{1}{2}$ pounds; potash, 19 pounds.

The fertilizers used per plot (in addition to nitrate of soda and sulphate of potash which were used alike on each as stated above) are shown below: —

Plot 1: hoof meal, $11\frac{3}{4}$ pounds. Plot 2: hoof meal, $11\frac{3}{4}$ pounds; apatite, 32 pounds. Plot 3: hoof meal, $11\frac{3}{4}$ pounds; South Carolina rock phosphate, 47 pounds. Plot 4: hoof meal, $11\frac{3}{4}$ pounds; Florida soft phosphate, $45\frac{1}{2}$ pounds. Plot 5: hoof meal, $11\frac{3}{4}$ pounds; slag, $67\frac{1}{4}$ pounds. Plot 6: hoof meal, $11\frac{3}{4}$ pounds; Navassa phosphate, 49 pounds. Plot 7: hoof meal, $11\frac{3}{4}$ pounds. Plot 8: hoof meal, $11\frac{3}{4}$ pounds; dissolved bone-black, 70 pounds. Plot 9: hoof meal, $\frac{6}{16}$ pound; raw bone meal, 45 pounds. Plot 10: hoof meal, $1\frac{3}{16}$ pounds; dissolved bone meal, $73\frac{1}{4}$ pounds. Plot 11: steamed bone meal, $48\frac{1}{4}$ pounds. Plot 12: hoof meal, $11\frac{3}{4}$ pounds; acid phosphate, $90\frac{1}{2}$ pounds. Plot 13; hoof meal, $11\frac{3}{4}$ pounds.

The variety of corn raised was Sibley's Pride of the North, which was planted on May 17, replanted as far as necessary on June 1, and thinned to one plant per foot in the drill early in June. The extraordinary precipitation of the season kept the soil too wet the greater part of the time during the month of July, and the crop was prevented from doing its best. It was cut and stooked September 21, and husked about the last of October.

The yield per plot and the calculated rates per acre are shown below: —

NAMES.	Corn (Pounds).	Stover (Pounds).	Corn per Acre (Bushels).	Stover per Acre (Pounds).
Plot 1, no phosphate, . . .	585	580	58.500	4,640
Plot 2, apatite, ...	565	475	56.500	3,800
Plot 3, South Carolina rock phosphate	645	535	64.500	4,280
Plot 4, Florida soft phosphate, .	725	620	72.500	4,960
Plot 5, phosphatic slag, . .	620	620	62.000	4,960
Plot 6, Navassa phosphate, . .	678¼	610	67.825	4,880
Plot 7, no phosphate, . . .	643¼	542	64.325	4,336
Plot 8, dissolved bone-black, .	618¼	548	61.825	4,384
Plot 9, raw bone meal, . . .	673¼	570	67.325	4,560
Plot 10, dissolved bone meal, .	633¼	550	63.325	4,400
Plot 11, steamed bone meal, . .	503¼	450	50.325	3,600
Plot 12, acid phosphate, . .	628¼	540	62.825	4,320
Plot 13, no phosphate, . . .	673¼	590	67.325	4,720

It will be noticed that one of the best crops in the field was produced where no phosphate was used, and that the yield on the plots to which phosphates were applied varies without apparent relation to the availability of the phosphoric acid in the materials used. Under these circumstances, extended discussion of the results is not called for.

The unfavorable influence of the season and possible differences in natural fertility of the soil serve to obscure the action of the phosphates employed.

Leguminous Crops (Clover, Pea and Bean, or "Pod" Family) as Nitrogen Gatherers. (Field A.)

A full history of the field since 1884 is given by Dr. Goessmann in our ninth annual report. The years 1884–88 were preparatory; the experiment proper began in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and barn-yard manure as sources of nitrogen.*

The field is divided into eleven $\frac{1}{10}$ acre plots, numbered from 0 to 10. Three plots, 4, 7 and 9, have received no application of nitrogen-containing manure or fertilizer since 1884. One (0) has received barn-yard manure; two (1, 2), nitrate of soda; three (5, 6, 8), sulphate of ammonia; and two (3, 10), dried blood every year since 1889. These materials have been used in such amounts as to furnish nitrogen at the rate of 45 pounds per acre each year. All the plots have received, yearly, equal amounts of phosphoric acid and potash. The quantities applied have furnished, per acre, phosphoric acid 80 pounds, and potash 125 pounds, from 1889 to 1894 and the past season. In 1895 and 1896 double these quantities were used. Dr. Goessmann reports: † —

> The total yield of crops on the plots receiving no nitrogen, as compared with those receiving nitrogen, was in the several years as follows: —
>
> With corn in 1889, one-fifth less.
> With oats in 1890, one-fifth to one-sixth less.
> With rye in 1891, one-fifth to one-sixth less.
> With soya beans in 1892, one-third to one-fourth less.

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* Only such details are given here as are necessary to a general understanding of the subject; full information is found, as stated above, in our ninth annual report.

† Ninth annual report, Hatch Experiment Station, page 175.

In 1893 the crop was oats, and the yield of grain was from one-seventh to one-eighth less on the plots receiving no nitrogen than the average of those receiving nitrogen. Here the interposition of a leguminous crop (soya bean in 1892) appears to have lessened the proportional inferiority of the plots which received no nitrogen. In 1894 the crop was again the soya bean. The plots without nitrogen give a yield about one-third less than the average of the others. Thus far it will be seen that the soya bean has not shown that degree of independence of soil nitrogen of which it is supposed to be capable. To an even greater degree than the grain crops it is benefited by nitrogen manuring. This fact may perhaps be accounted for because of conditions unfavorable to bacterial life in this soil; but as to the nature of such unfavorable conditions we are at present ignorant.

In 1895 the crop was oats, and results showed no improvement in proportional yield on the plots receiving no nitrogen which could be attributed to the preceding bean crop. This may be in part due to the fact that the bean has a rather limited root system, and leaves behind but little stubble.

In 1896 the crop was again the soya bean, which once more showed marked inferiority on the no-nitrogen plots. An attempt to seed the land to clover in the standing beans proved a failure, on account of the dry season and the too dense shade made by the crop of beans.

The crop the past season has been oats. The yield per plot of straw and grain, the rate per acre and remarks upon the quality of the grain are given below. In this table the no-nitrogen plots are italicised.

Nitrogen Experiment.

PLOT.	Weight per Plot One-tenth Acre.		Yield per Acre.		Remarks on Grain.
	Straw (Pounds).	Oats (Pounds).	Straw (Pounds).	Oats (Bushels).	Kernels.
Nitrate of soda, . .	500	159	5,000	49.68	Light.
Nitrate of soda, . .	400	147	4,000	45.93	Light.
Dried blood, . .	215	122	2,150	38.12	Good.
No nitrogen, . .	*120*	*69*	*1,200*	*21.56*	Good.
Sulphate of ammonia, .	340	137	3,400	42.81	Poorer than No. 3.
Sulphate of ammonia, .	275	97	2,750	30.31	Good.
No nitrogen, . .	*120*	*77½*	*1,200*	*24.21*	Good.
Sulphate of ammonia, .	350	127	3,500	39.68	Good.
No nitrogen, . .	*130*	*75*	*1,300*	*23.43*	Good.
Dried blood, . .	220	126	2,200	39.37	Fair.
Barn-yard manure, .	220	125	2,200	39.06	Fair.

Calculation shows that the average total weight of crop is a little less than one-half as great on the plots not manured with nitrogen as the average of the other plots. The crop of grain is a little more than one-half as great. We find, then, not the least evidence of any ability on the part of the soya bean when grown before a grain crop (and harvested) to make nitrogen manuring of the grain crop unnecessary. On the contrary, the proportional yield of the no-nitrogen plots is this year the lowest it has ever been in these experiments.

The Relative Value of the Different Manures furnishing Nitrogen.

The nitrate of soda gives the largest crop. Next in order of yield come the barn-yard manure, dried blood and sulphate of ammonia; but between these there is not much difference. On plots 2, 3, 4, 6, 7, 8 and 9 the source of potash is the muriate; on all others it is double sulphate of

potash-magnesia. The yield of oats is in every instance greater where the sulphate is used under otherwise similar manuring. The superiority is most marked when sulphate of ammonia is the source of nitrogen.

Muriate compared with Sulphate of Potash in connection with Sulphate of Ammonia for Corn.

Results obtained with different crops in the special nitrogen tests on Field A during previous years having indicated an injurious effect, due to the combination of muriate of potash and sulphate of ammonia,* it was decided to undertake experiments upon a larger scale, with the view of bringing out more clearly the significance or importance of this effect. Accordingly two plots of land of one-half acre each, lying on the east side of the highway, were set apart for this experiment. This land had previously been used in experiments to determine the relative value of phosphatic slag and ground bone as sources of phosphoric acid. These experiments were begun in 1894 and continued until 1896. The crops had been oats, corn and millet. An account of these experiments will be found in the annual reports covering the years named.

The following fertilizers were applied this year, broadcast, after ploughing, and harrowed in: —

North plot: sulphate of ammonia, 152 pounds; muriate of potash, 120 pounds; acid phosphate, 160 pounds.

South plot: sulphate of ammonia, 152 pounds; sulphate of potash, 120 pounds; acid phosphate, 160 pounds.

The fertilizers were applied May 11. The crop was planted in drills three and one-half feet apart, May 17. The variety was Sibley's Pride of the North.

The soil throughout the season was too wet for the best growth of the corn crop. The crop was harvested on September 6, and put into the silo. The yield was as follows:

* For a full discussion of this subject see Dr. Goessmann's paper in the annual report of the Hatch Experiment Station for 1897, pages 222 and 223.

north plot, 5,760 pounds; south plot, 5,255 pounds. The difference is too small to afford a basis for a positive judgment as to the merits of the two forms of potash applied.

Fertilizers for Garden Crops.

In 1891 Dr. Goessmann began a series of experiments for the comparison of sulphate of ammonia, nitrate of soda and dried blood as sources of nitrogen for various garden crops. Sulphate of potash was employed to furnish potash. In 1892 the scope of the experiment was enlarged by including three additional plots, comparing the same materials as sources of nitrogen with muriate of potash used as a source of potash. The results of these experiments are fully discussed in Dr. Goessmann's reports. The following table shows the different fertilizers applied to the several plots: —

PLOTS.	Annual Supply of Manurial Substances.	Pounds.
Plot 1,	Sulplate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The crops raised during the past year were garden peas, beets, squashes and celery.

Garden Peas. — The land was ploughed April 19, fertilizers applied and harrowed in April 21, and the seed planted on April 22. On June 7 it was noticed that the growth of the vines on Plot 1 was distinctly inferior to that on the other plots, and it so continued throughout the season. The pods produced by the vines upon this plot were short, but well filled, as were they also upon Plot 4. The growth of vines upon plots 3 and 6 may be characterized as medium; upon plots 2 and 5 the growth was rank. The pods upon these two plots were large, but not well filled. Three pickings of peas were made. The yield of green peas, as well as of vines, is shown in the following table: —

Green Peas (Pounds).

DATE.	MURIATE OF POTASH.			SULPHATE OF POTASH.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
July 12, ...	100	93	99½	165	179	195
July 19, ...	66	150	132	143	134	91
July 23, ...	11	60	49	40	30	21
	177	203	280½	348	343	307

Green Vines (Pounds).

July 23, ...	102½	210	240	240	205	180

The average yield of green peas produced by the different fertilizers is shown in the following table: —

	Pounds.
Average of muriate plots, ...	220⅙
Average of sulphate plots, ...	332⅔
Average of sulphate of ammonia plots, ...	262½
Average of nitrate of soda plots, ...	273
Average of dried blood plots, ...	293¾

It will be noticed that the sulphate of potash appeared to be distinctly superior to the muriate, that the dried blood gives a larger crop than either of the other sources of nitro-

gen, but that there is not a great difference between the three materials used to supply this element. The best crop is produced where sulphate of ammonia and sulphate of potash are used. The crop where nitrate of soda and sulphate of potash are used is not, however, materially inferior.

Beets. — The variety raised was the Eclipse. Fertilizers were applied as stated above, seed planted April 22, vacancies filled May 20. The growth of the beets upon Plot 1 was noticed early in the season to be distinctly inferior to that on the other plots, and before the close of the season most of the plants upon this plot were dead. On July 27 the crop was harvested. The yield of the several plots was as follows: Plot 1, 133 pounds; Plot 2, 711 pounds; Plot 3, 358 pounds; Plot 4, 448 pounds; Plot 5, 793½ pounds; Plot 6, 478 pounds.

The averages of the different fertilizers are shown below: —

	Pounds.
Average of muriate plots,	400⅔
Average of sulphate plots,	573⅙
Average of sulphate of ammonia plots,	290½
Average of nitrate of soda plots,	752¼
Average of dried blood plots,	418

It will be noticed that the sulphate of potash appears to be greatly superior to the muriate, and nitrate of soda is far ahead of sulphate of ammonia as a source of nitrogen for this crop. The best yield is produced where nitrate of soda and sulphate of potash are used together.

Squashes and Celery. — Both of these crops were failures, on account of the unfavorable weather. The celery plants, it is true, lived, but many of them made no growth. The plants were cut close to the ground on October 18, many of them being, if anything, smaller than when set. The cuttings were weighed, with the following results: Plot 1, 28½ pounds; Plot 2, 57 pounds; Plot 3, 35½ pounds; Plot 4, 28 pounds; Plot 5, 92 pounds; Plot 6, 24 pounds.

It is noticeable that here again Plot 5, where nitrate of soda and sulphate of potash were used, is the best; but even this did not produce a crop with any marketable value.

Injurious Effect of Sulphate of Ammonia and Muriate of Potash used together. — Particular attention is called to the fact that upon Plot 1, where sulphate of ammonia and muriate of potash are used together, the growth was, in the case of the peas and beets, decidedly inferior to that upon the other plots. This inferiority may undoubtedly be ascribed to the poisonous effect of the chloride of ammonia formed where these fertilizers are used together, to which Dr. Goessmann has called especial attention.

Experiments on Grass Land.

The system of manuring grass lands, planned by Dr. Goessmann and described by him in previous reports, has been continued. According to this system, the land receives one year a dressing of barn-yard manure at the rate of 8 tons per acre; the next year, wood ashes at the rate of 1 ton per acre; and the third year, ground bone 600 pounds, and muriate of potash 200 pounds, per acre.

Plot 1, which this year received ashes, gave a yield at the rate of 5,775 pounds of hay and 3,204 pounds of rowen per acre, — a total of 4 tons 979 pounds. Plot 2, which received manure applied in the fall of 1896, produced at the rate of 5,784 pounds of hay and 2,627 pounds of rowen per acre, — a total of 4 tons and 411 pounds. Plot 3, which this year received bone and potash, produced at the rate of 6,183 pounds of hay and 2,755 pounds of rowen per acre, — a total of 4 tons 938 pounds.

This system of using these different manures for grass lands in rotation has much to recommend it. It is simple, and has certainly given remarkably good crops. I believe, however, that the system would be improved by the use of a little nitrate of soda, say 150 pounds per acre, with the ashes as well as with the bone and potash.

Experiments with Nitragin, a Germ Fertilizer.

Nitragin, prepared according to the directions of Professor Nobbe, was imported at my suggestion from Germany in the summer of 1896. The material was fully described

by Dr. Goessmann in our last annual report, and full directions for its use are quoted by him.

The nitragin has been tried in accordance with directions, as stated elsewhere in this report, upon crimson clover and alfalfa, without apparent benefit. It has also been tried upon common red clover. On this crop, as with the others, no difference in growth attributable to the nitragin has been noticed; and, so far as can be judged at the present time, the use of this germ fertilizer for our common clovers is not to be advised. Nitragin undoubtedly contains the germs of the appropriate nodular bacteria, — the name of Professor Nobbe is sufficient guarantee of this. The failure of the material to benefit the crop appears to be due to the fact that our soils contain the nodular bacteria of the common leguminous crops in sufficient numbers so that the addition of a few more by the use of nitragin counts for nothing. Experience in the open field in most parts of Germany and England has been similar to our own, and I believe that we may safely conclude that only when we are about to begin the culture of a leguminous crop new to a particular locality will it be found advantageous to employ nitragin. In such cases the soil lacks the appropriate nodular bacteria; nitragin furnishes these, and the result is a better growth, because the crop is enabled to make use of the free nitrogen of the air from the first, which it could not do in the absence of the proper bacteria.

Sulphate of Iron as a Fertilizer.

Sulphate of iron has been tried during the past season upon the same plots as in 1896, but this year with corn as a crop. The sulphate of iron is used at the rate of 80 pounds per acre. The crop where it was employed was a little inferior to that on the plots where it was not used. Without sulphate of iron the average yield of the plots was $58\frac{1}{4}$ pounds of corn and $163\frac{1}{4}$ pounds of stover; with sulphate of iron, $50\frac{3}{4}$ pounds of corn and 160 pounds of stover.

Variety Tests.

1. *Corn.*

Twenty of the more promising varieties of corn tried for the first time last year have been given a further trial during the past season. Nine of these varieties were flint corns, as follows, named in the order of productiveness: Sanford, Longfellow, Waushakum, Giant Long White, Rhode Island White Cap, Early Canada, King Philip, Angel of Midnight, Compton's Early. The varieties of dent corn, named in order of productiveness, were Early Butler, Leaming Field, Champion White Pearl, Queen of the Prairie, Iowa Gold Mine, King of the Earlies, Sibley's Pride of the North, South Dakota White, Huron Extra Early, Wisconsin Yellow and White Cap Yellow.

Varieties the ears of which were very moist when husked are Queen of the Prairie and Huron Extra Early. Varieties which were moist are White Cap Dent, Leaming Field, Iowa Gold Mine and Champion White Pearl.

All of the varieties in these two classes are too late for culture as grain crops in this locality, though they would do for the silo.

2. *Potatoes.*

Eighty-one varieties of potatoes were cultivated for purposes of comparison upon the general plan described in our last report (ninth). The soil was a well-drained medium loam. The fertilizers used per acre were as follows: —

	Pounds.
Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed and scattered broadly in the furrows before dropping the seed. The seed was planted April 30. May 5 the crop was somewhat injured by washing of the soil between the rows and by the excessive rainfall. The potatoes were dug September 26 to October 6. The yield was at the rate of from 115.7 to 282.4 bushels per acre. The eleven largest yields of merchantable tubers,

in the order of productiveness, were given by the following varieties: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these gave a product at the rate of more than 220 bushels of merchantable tubers per acre. Again, as last year, we find the two old standard sorts, Early Rose and Beauty of Hebron, ranking among the very best. It appears doubtful whether any among all those tried are truly superior to these varieties.

Twenty-three varieties have given yields of merchantable tubers at the rate of less than 175 bushels per acre. These, in the order of inferiority, are the following: Minister, Bill Nye, Harbinger, Peerless, Jr., Livingston Banner, Burpee's Extra Early, Carmen No. 3, Dandy, Early Market, Crown Jewel, Merriman, White Star, Irish Daisy, Chance, Six Weeks, Alliance, Sunlit Star, World's Fair, Freeman, Ohio, Jr., Great Divide, Wise Seedling and Early Norther.

All of the varieties grown this year are to be examined for determination of dry matter and starch, but this work could not be completed in season for this report. Full details as to the varieties cultivated are therefore reserved until these analytical results can be published.

3. *Grasses.*

Sixty species and varieties of grasses have been under trial. Most of them occupied plots containing one square rod. About one-half of these grasses were sown in the spring of 1896. Among those so sown the following varieties winter-killed: English rye grass, Italian rye grass, crested dog's-tail and meadow fescue. Among comparatively little-cultivated varieties which appear promising may be mentioned the following: tall oat grass, tall fescue, red fescue, fowl meadow, Canada blue-grass, water-spear grass and wood-meadow grass.

The yield of the dry matter in the hay and rowen (where any was secured) of those varieties sown in the spring of 1896 during the past season, with date of cutting of both

the first and the second crops, is shown in the following table. The area in each variety was one square rod.

KINDS.	Date of cutting Hay.	Dry Matter in Hay (Pounds).	Date of cutting Rowen.	Dry Matter in Rowen (Pounds).
Timothy (*Phleum pratensis*), .	July 1,	19.36	Sept. 11,	6.44
Awnless Broom (*Bromus inermis*),	June 25,	14.71	Sept. 11,	6.44
Yellow Oat (*Avena flavescens*), .	July 1,	–	Sept. 11,	4.41
Sweet Vernal (*Anthox anthum odoratum*).	June 4,	2.98	Sept. 11,	4.41
Meadow Foxtail (*Alopecurus pratensis*).	May 17,	5.70	June 25,	7.87
Red-top (*Agrostis vulgaris*), . .	July 6,	31.12	Sept. 11,	8.44
Rhode Island Bent (*Agrostis Canina*).	July 6,	30.81	Sept. 11,	6.41
Fall Oat (*Arrhenatheum avenaceum*).	June 25,	22.85	Sept. 11,	11.86
Glyceria fluitans, ...	July 1,	–	Sept. 11,	–
Meadow soft (*Holcus lanatus*), .	June 25,	10.25	Sept. 11,	6.42
Slender Fescue (*Festuca tennuifolia*).	June 15,	21.43	–	–
Meadow Fescue (*Festuca pratensis*).	Sept. 11,	4.36	–	–
Sheep's Fescue (*Festuca ovina*), .	June 15,	27.85	Sept. 11,	6.61
Tall Fescue (*Festuca elatior*), .	June 25,	27.20	Sept. 11,	17.81
Hard Fescue (*Festuca durinscula*),	June 15,	27.42	Sept. 11,	–
Orchard (*Dactylis glomerata*), .	June 15,	16.41	Sept. 11,	11.96
Red Fescue (*Festuca rubra*), .	June 25,	27.47	Sept. 11,	–
Fowl Meadow (*Poa serotina*), .	July 6,	43.00	Sept. 11,	14.27
Rough-stalked Meadow (*Poa trivialis*).	July 1,	9.87	Sept. 11,	–
Kentucky Blue (*Poa pratensis*), .	June 15,	14.73	Sept. 11,	18.93
Canada Blue (*Poa compressa*), .	July 10,	43.68	Sept. 11,	6.17
Water Spear (*Poa aquatica*), .	July 1,	31.97	Sept. 11,	8.04
Canary Reed (*Phalaris arundinaria*).	June 25,	23.18	Sept. 11,	21.09
Wood Meadow (*Poa nemoralis*), .	July 1,	31.07	Sept. 11,	12.88
Creeping Bent (*Agrostis stolonifera*).	July 6,	15.27	Sept. 11,	–

4. *Millets.*

Twenty-one varieties of millet, occupying one square rod each, were grown for purposes of comparison on medium loam, manured at the rate of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. These were of three species, *Panicum crus galli*, *P. miliaceum* and *P. italicum*. The varieties grown, with particulars concerning amount of seed sown, date of heading, height of plants, and the weight per plot and acre of hay produced, are shown in the table below: —

KINDS.	Ounces Seed Sown.	Date of Heading.	Date When Cut.	Height of Plants (Feet).	Weight, Air Dry, Square Rod (Pounds).	Weight per Acre (Pounds).
Panicum crus galli.						
Japanese barn-yard, . . .	1	Aug. 2,	Aug. 17,	6	65	10,400
Japanese barn-yard, loose headed.	1	Aug. 2,	Aug. 17,	6	63	10,080
Panicum miliaceum.						
Common broom corn, . .	3	July 19,	Aug. 2,	4	51	8,160
Japanese broom corn, red seed,	3	Aug. 2,	Aug. 21,	4 -6	83	13,280
Japanese broom corn, white seed.	5	Aug. 10,	Aug. 29,	5½-6	92	14,720
California, ...	4	July 19,	Aug. 2,	4	62	9,920
Chinese, ...	4	July 23,	Aug. 5,	4	69	11,040
French, ...	4	July 23,	Aug. 5,	4	66	10,560
White French, ...	4	July 19,	Aug. 2,	3½-4	65	10,400
Red French, ...	4	July 19,	Aug. 2,	-	65	10,400
Hog, ...	4	July 19,	Aug. 2,	3 -3½	63	10,080
Panicum italicum.						
Canary bird seed, . . .	4	Aug. 7,	Aug. 2,	-	40	6,400
Dakota, ...	4	July 23,	Aug. 12,	3½-4	60	9,600
Early Harvest, ...	4	July 19,	Aug. 2,	3 -3½	57½	9,340
Golden, ...	3	Aug. 21,	Sept. 4,	5	100	16,000
Golden Wonder, . . .	4	Aug. 10,	Sept. 4,	5	95	15,200
Japanese Glutenous Hokkaido,	3	Aug. 12,	Aug. 26,	4½	63	10,080
Japanese Glutenous Mukoda-mashi.	3	-	Sept. 15,	2 -4	100	16,000
Japanese common Millet, .	3	Aug. 12,	Aug. 26,	4¾	88	14,080
New Siberian, ...	4	July 28,	Aug. 12,	3 -4	55	8,800

The differences in yield are large, but the scale upon which the varieties were grown is small, — too small, in my judgment, to justify sweeping conclusions as to the relative merits of the several sorts.

The "Dakota" closely resembles the "Early Harvest;" the "loose-headed" variety of the "barn-yard" millet is much less leafy and less valuable than the common form. The so-called "Golden Wonder" cultivated appeared to be like the "Golden." The "Japanese Glutenous," from "*Mukodamashi*," is very late, and does not mature with us. The variety of glutenous millet from *Hokkaido* appears to be a valuable sort. Moisture tests which are being made will very likely change the relative position of some varieties.

5. *Japanese Millets for Seed.*

A small area of each of our three leading varieties of Japanese millets was grown for seed. The soil was fertilized for each variety at the following rate per acre, the fertilizer being sown broadcast and harrowed in: —

Manure,	4 cords.
Nitrate of soda,	125 pounds.
Dried blood,	100 "
Tankage,	200 "
Superphosphate,	250 "
Muriate of potash,	200 "

The season was not very favorable for these crops, and they were somewhat injured on several occasions by the washing of the soil, due to excessive rain-fall.

Barn-yard Variety (*Panicum crus galli*). — The area sown to this variety was .633 acres. The seed was sown May 27, in drills, and was cultivated and hand-weeded. It yielded 1,370 pounds of seed and 4,360 pounds of straw, which is at the rate of 40 bushels of seed and 3 tons 888 pounds of straw per acre.

Japanese Broom-corn Millet (*Panicum miliaceum*). — The area of this variety was .248 acres. It was planted and cultivated like the preceding variety. The yield was 535 pounds of seed and 1,620 pounds of straw, which is at

the rate of 40 bushels of seed and 3 tons 532 pounds of straw per acre.

Japanese Millet (*Panicum italicum*). — The area of this variety was .138 acres. It was planted and managed in all respects like the preceding varieties. The yield was 305 pounds of seed and 519 pounds of straw, which is at the rate of 41 bushels of seed and 1 ton 1,761 pounds of straw per acre.

6. *Soya Beans.*

A small area of each of the three leading varieties of Japanese soya beans was cultivated for seed. The yield was at the following rates per acre: early white, 18.7 bushels; medium black, 16 bushels; medium green, 34.5 bushels. The last-named variety thus once more demonstrates its great superiority as a crop-producer over either of the other sorts under trial.

7. *Clovers.*

Tests were begun in 1895 for the purpose of comparing four of our prominent clovers, viz., medium red, mammoth, alsike and crimson. The result of the first year's test will be found in our ninth annual report (pages 27 to 29). As stated in that report, our results indicate that the crimson will not prove valuable as a fodder crop in this locality.

Medium Red Clover. — The crop of this variety compared very favorably with that of the mammoth clover in the season of 1896, but during the winter of 1896 and 97 the plants of this variety were nearly all killed. The plots were accordingly ploughed and sown with oats and vetch.

Mammoth Clover. — This variety was somewhat injured by the winter, but was allowed to stand. Bad weather prevented its being harvested at the proper time, and it was much damaged before it could be secured. It yielded at the rate of about 1½ tons per acre at the first cutting. The second growth was much mixed with weeds. It was cut and weighed green, yielding at the rate of about 2,800 pounds per acre.

Alsike Clover. — This variety, like the preceding, was much injured by rain. It, like the mammoth, was found to have suffered much during the winter. The crop cut was

much mixed with weeds, yielding at the rate of $2\frac{1}{4}$ tons per acre for the first cutting. The second growth was mostly weeds, and was weighed green, amounting to about 5 tons per acre.

Conclusion. — The mammoth clover under the conditions of our experiment has shown greater vitality and productive capacity than either of the other sorts. It is worthy more extensive cultivation.

Sulphate v. Muriate of Potash for Clovers. — As stated in our ninth annual report, there were two plots of each of the varieties of clover under comparison, one fertilized with muriate of potash, the other with sulphate of potash. The results in 1896 showed no material difference in yields which could certainly be ascribed to the nature of the potash salts used. The same is true this year.

The sulphate plots, both of the mammoth and the alsike clovers, yielded most at the first cutting; the muriate plots, in both cases, yielded most at the second cutting; but, as stated, the crops secured at the second cutting were largely mixed with weeds. The results, therefore, must be regarded as without especial significance.

8. *Sweet Clover (Melilotus alba).*

This crop occupied two plots of two-fifteenths of an acre each, in Field B. The same crop was grown upon these plots in 1896, and the results are fully discussed in our ninth annual report. The growth during that season was for the most part small and unsatisfactory, owing apparently to the fact that the appropriate nodular bacteria were not present in sufficient numbers to enable the crop to make use of free atmospheric nitrogen. A few of the plants in 1896 were found to have abundant nodules upon their roots. These showed a deep-green color and made a vigorous growth. It was judged that, if the land should be thoroughly worked in various directions, the nodular bacteria would be scattered throughout the soil, and that the second crop upon the same land would be better than the first. The soil was accordingly thoroughly prepared, and the seed for the crop of this year sown at the rate of 10 pounds per acre on July 30, 1896.

The growth was very much superior to that of the previous year, and upon examination in the early part of the season it was found that the roots of about one-half the plants were abundantly supplied with nodules. These plants were making a vigorous growth, and had a deep-green color, indicative of an abundant supply of nitrogen. They were at this time evidently able to draw upon the atmosphere for this element. Later the other plants in the field seemed also to gain this ability.

On July 8 the crop averaged 6 feet in height. A portion was cut and fed to the cows kept in the department of foods and feeding. This portion yielded at the rate of about 12½ tons per acre. Dr. Lindsey reports that the cows ate it readily and appeared to be fond of it. It was, however, rather coarse for feeding when allowed to stand until the latter part of July. If to be fed, the crop should be cut early. In average seasons it would be at its best condition during the first half of the month of July. It is not, however, as a fodder crop that I am inclined to recommend a trial of sweet clover, but rather as a crop for green manuring. I believe it may serve here a similar purpose to that served by crimson clover in localities where it is hardy.

Miscellaneous Crops.

Alfalfa. — One-quarter of an acre of light soil was sown on April 17 with alfalfa. The fertilizer applied to the quarter acre was as follows: fine-ground bone, 100 pounds; nitrate of soda, 50 pounds; phosphatic slag, 50 pounds; muriate of potash, 50 pounds. One-half the seed used was treated with nitragin. All the seed germinated quickly, no difference being noticed between the treated and the untreated. The small plants were, however, injured by the heavy rains, and up to date the crop has made but a feeble growth.

Saccaline. — Our trial of this crop has been carried out upon two small plots, the one having a heavy, moist soil, the other a light, drier soil. One-year-old plants were set in the spring of 1896. The growth during that season was feeble. In August of that year each plot was given a good

dressing of manure. In the spring of 1897 it was found that a considerable number of the plants had been winter-killed. On the heavy soil 36 out of 408, and on the lighter soil 71 out of 129, were dead; of 451 plants left in a nursery, 258 were dead. Plants which lived through the winter were well started by April 20, but the new growth was killed by a frost. On July 16 the growth, which ranged from 1 to 7 feet in height, the average being about 3 feet, was cut. The plants were large and woody. The yield on the heavy soil, 408 plants, was 295 pounds; on the lighter soil, 129 plants, 132 pounds. The leaves only were eaten by cows, — horses would not eat it at all. A second crop was not cut, but on October 1, when the plants were killed by frost, the second growth averaged about 18 inches in height. As a result of our trial of this crop, I am convinced that it is without value as a fodder crop for us.

Crimson Clover. — A further trial of this crop has been made upon a rather light soil. The seed was sown July 3 with equal parts of winter rye. Nitragin, not received in season to apply with the seed, was mixed with water, according to directions, and applied to the clover August 31, the plants then standing about 2 inches high. The crop was a complete failure, every plant being winter-killed.

Winter Vetch. — A small plot of this crop has been grown upon a light soil. It was sown August 20, equal parts of vetch and rye. This vetch proved perfectly hardy and grew vigorously, reaching a greater height than the rye. This vetch will prove valuable as a green fodder when sown with winter rye.

Besides the above, we have cultivated a few rows each of a large variety of fodder plants, some 39 in number. In this variety are included a large number that have been mentioned in previous reports, and they do not require further notice at this time.

Among those cultivated for the first time this year are the *Idaho field or coffee pea* (*Cicer arietinum*). This appears to be the same as the gram or chick pea, which we have had under cultivation for two years. The growth is too small to make it valuable for a fodder crop.

Another new fodder crop for this year was the *Brazilian stooling flour corn.* The plants made a vigorous growth, but are judged to be too coarse and woody to prove of much value for fodder.

Black chaff or African millet is another crop under trial this year for the first time. It appears to be the same as Kaffir corn, and, as reported last year, our experience leads us to regard this fodder crop as inferior to maize for our climate.

A Reputed Method for Destroying Stumps.

A correspondent in one of our agricultural papers during the summer of 1895 reported that he had found it possible to destroy stumps in the following manner : —

A hole one or two inches in diameter according to the size of the tree, and eighteen inches deep, is to be bored in the stump. Into this put from one and one-half to two ounces of saltpetre, fill with water and plug tightly. Six months later, put into the same hole about one gill of kerosene oil, and set fire to it. The correspondent stated: "The stump will smoulder away without blazing, even down to every part of the roots, leaving nothing but ashes."

On Nov. 4, 1895, fifty stumps of trees cut in 1894, including the following varieties, maple, hickory, hemlock, white pine, yellow birch and elm, were bored according to directions. On December 11 saltpetre and water were put into the holes, according to directions, and the holes plugged. During July, 1896, the plugs were removed, the holes were filled with kerosene, and an attempt made to burn the stumps. It was found that not even the oil would burn. A portion of the stumps were left until June, 1897, when another attempt was made to burn them, using a low-test oil, called paraffine gas oil. The stumps are still in the field. The method has been given a thorough trial, but must be regarded as a complete failure.

Poultry Experiments.

Experiments with poultry were carried out during the winter of 1896 and 1897. Our attention was confined to three points : —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of dry-ground animal meal and cut fresh bone.

3. Comparative value for egg-production of cut clover and fresh cabbage.

General Conditions.

In all of these experiments pullets purchased in Plymouth County and sent to us in December were used. A few had laid before we received them, and production was stopped by the move, as is generally the case. Some of the pullets moulted after reception here, which served to reduce the egg yield. Each of the six lots of fowls occupied a house, with roosting and laying room ten by twelve feet, and scratching shed eight by twelve feet in size. Each had the liberty of a large yard, which furnished a little grass after April 15, but in all alike. Each of the feeding trials began January 1 and continued until May 2, — 122 days.

Soft foods were mixed for the morning mash with boiling water the night before using. Sufficient of the materials for a fortnight were mixed dry at one time. Oats were always scattered in the straw in the shed at noon. At night the wheat was fed in the same manner. As a rule, a little cut bone was fed once a week, in place of the noon ration of oats. About twice a week cabbage was hung up in each coop except the one where cut clover was under comparison with this vegetable. Clear water, shells and grit were before the fowls all the time. Occasionally salt was added to the morning mash. At the conclusion of the experiment the dressed fowls were sent to G. M. Austin & Son, Boston, who reported upon the quality of the several lots.

1. Effect of Condition Powder upon Egg-production.

This experiment was carried out in most respects in the same manner as last year. Light Brahmas were selected for this test, 20 in the coop receiving condition powders and 19 in the other. The food of the two lots was the same

in kind, with the exception that the fowls in House No. 6 received daily condition powder in the morning mash, in accordance with directions furnished with the powder.

The kinds and amounts of food used are shown in the table: —

KINDS.	AMOUNTS (POUNDS).	
	No Condition Powder.	Condition Powder.
Wheat,	209	220
Oats,	150	150
Bran,	27	28
Middlings,	27	28
Animal meal,	27	28
Clover,	27	28
Cabbage,	28	29
Corn meal,	28	29¼
Bones,	9	9

About three pounds of condition powders were used in the experiment.

The weights of the fowls were taken at intervals, and were as follows: —

Average Weights (Pounds).

	No Condition Powder.	Condition Powder.
January 4,	4.868	4.650
February 4,	5.260	4.950
March 9,	5.360	5.343
April 26,	5.310	5.470
May 3 (after fasting twelve hours),	5.160	5.180
Dressed weight,	4.605	4.657

The results and leading details are shown below: —

Condition Powder for Egg-production.

Experiment January 1 to May 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
No condition powder,	2,318	$6 61	$0 00285	$0 0124	532	65	1½	1.958
Condition powder, .	2,354	6 68	00280	0125	540	67	4	1.993

The nutritive ratio was 1 : 5.16 for the fowls not receiving condition powder; for the others, 1 : 5.14,—practically identical. The total dry matter in food consumed for each egg produced was: without condition powder, 0.8349 pounds; with powder, 0.8688 pounds. Besides the perfect eggs as shown in above table, the fowls receiving no condition powders laid three soft-shelled eggs; the others, one. There were five sitters in the first lot, eleven in the second.

Samples of the eggs were analyzed, and those from the condition-powder fowls were found somewhat richer in dry matter, protein and fat. The eggs were also tested in two families by careful house-keepers. The reports did not agree in all particulars; but one of the two found the eggs from the fowls which had received condition powders superior in flavor of yolk, flavor of white, in beating qualities and in consistency; the eggs from the other fowls better in color and size of yolks. The other reported the condition-powder eggs strong in flavor and the yolks small. This discrepancy is probably to be accounted for from the fact that the number tested was small. Individual as well as class differences would almost certainly be found in the eggs.

The fowls which had received condition powder were reported as dressing rather better than the other lot.

One fowl in the condition-powder house died during the test; there were no losses in the other house.

In conclusion, I have to say that the differences found in this experiment are too small to be considered decisive. On the side of the condition powder we have size of eggs and

weight and quality of the dressed fowls; against the powder, we have the food cost per egg, the weight of dry matter in food per egg, and the loss of one fowl. We are warranted simply in the statement that the powder does not appear to have paid for its use.

2. *Cut Bone v. Animal Meal for Egg-production.*

Each of the two houses contained twenty Plymouth Rock pullets in this experiment. The bone and animal meal were each mixed in the morning mash. The foods used are shown below: —

KINDS.	Cut-bone House (Pounds).	Animal-meal House (Pounds).
Wheat, ...	213	196
Oats, ...	149	149
Bran, ...	27	28
Middlings, ...	27	28
Buffalo gluten, ...	–	28
Animal meal, ...	–	28
Clover, ...	28	27
Cabbages, ...	26½	29⅓
Chicago gluten, ...	27	–
Cut bone, ...	28	–

The nutritive ratios in the two houses were 1 : 5.05 and 1 : 4.45 respectively.

The average weights of the fowls were as follows: —

	Cut-bone House (Pounds).	Animal-meal House (Pounds).
January 4, ...	4.75	4.89
February 6, ...	5.10	5.00
March 9, ...	5.86	5.28
April 27, ...	5.44	5.15
May 3 (after fasting twelve hours), . .	5.28	4.88
Dressed weight, ...	4.83	4.43

The dressed fowls which had received the cut bone were reported slightly better than the other lot. The leading details and results are shown in the following table: —

Cut Bone v. Animal Meal.

Experiment January 1 to May 2.	Number Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Cut-bone house, .	2,279	$6 61	$0 0028	$0 0130	508	64	9	2.0034
Animal-meal house, .	2,440	6 24	0025	0097	639	80	15	2.0270

There was, in addition to the eggs as shown by the table, one soft-shelled egg in each house. Two hens in the cut-bone house died during the experiment, from diarrhœa; those in the other house were healthy throughout the experiment.

The dry matter per egg was, where cut bone was fed, 0.877 pounds; on animal meal, 0.69 pounds. The number of sitters was 6 in the cut-bone house, 12 in the other.

A sample of eggs from each house was subjected to analysis. Those produced on the cut bone contained rather more protein but less fat than the other. A test for cooking quality was indecisive; one of the two house-keepers having preferred one lot; the other the opposite lot.

The advantage in this trial is, then, clearly with the animal meal as a food for egg-production. It has given more eggs of a greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer. The results this year are thus the opposite of those of last year. We have now repeated this experiment four times, with results twice favorable to the bone and twice to the animal meal, but have not before found so decisive a difference as this year. We repeat the experiment again this winter.

3. *Clover Rowen v. Cabbage for Egg-production.*

Plymouth Rock pullets were used in this experiment; but they were later-hatched fowls than those in the experiments already described. There were twenty fowls in each

of the two houses, at the beginning. One fowl died in each house during the experiment, from unknown causes. The cut clover was fed in the morning mash. Instead of the clover, a fresh cabbage was kept before the fowls in the other house.

The foods used are shown in the table : —

KIND.	Clover House (Pounds).	Cabbage House (Pounds).
Wheat,	223	212
Oats,	150	149½
Bran,	28	36
Middlings,	28	36
Animal meal,	28	34¾
Clover,	26	–
Cabbage,	–	46¾
Cut bone,	8½	8½
Oat meal,	28	36

The nutritive ratio was practically the same in both houses : viz., in the clover house, 1 : 4.99 ; in the other, 1 : 4.838.

The average weights of the fowls were as follows : —

DATES.	Clover House (Pounds).	Cabbage House (Pounds).
January 4,	4.560	4.530
February 4,	5.480	4.800
March 8,	5.420	5.350
April 27,	5.470	5.394
May 3 (after twelve hours fasting),	5.289	5.184
Dressed weights,	4.780	4.890

The leading results and details are shown in the table : —

Clover Rowen v. Cabbage for Egg-production.

Experiment January 1 to May 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Clover house, . .	2,356	$7 033	$0 0029	$0 0150	466	59	10	2.0472
Cabbage house, . .	2,423	6 988	0028	0118	588	75	1	1.9880

In addition to these, the fowls in each house laid one soft-shelled egg.

The advantage lies most decidedly with the fowls fed cabbages, in so far as numbers, weight and cost of eggs are concerned. The eggs from the clover house were, however, much superior in cooking and eating quality to those from the other. Both house-keepers reporting are most emphatic in the expression of their preference for the eggs from the fowls fed the clover. One reports : "The eggs from the clover lot are in every way superior." The other says : "They are superior in color, size of yolk and flavor ; " and adds that "they have the finest flavor of any eggs " she ever ate.

Analysis showed the eggs from the fowls fed cabbages to contain higher percentages of dry matter, protein and fat than the others. The superior richness of these eggs apparently renders them strong in flavor.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of the meteorological department during the past year has been in the main a continuation of that of previous years, with such minor changes as, after due consideration, have seemed advisable. The observations for temperature are now all taken in the ground shelter on the campus. The publication of the maximum and minimum temperatures taken in the observatory shelter was discontinued last year, owing to their unreliable character. For the same reason, the observations themselves were discontinued early in April the present year.

The usual bulletins, giving a summary of the records and weather for each month, have been published. An annual summary will be issued as soon as the records for the year are completed.

No material additions have been made to the equipment of the department during the year.

Arrangements have been made to furnish the New England Weather Bureau with the weekly snow reports, as was done last year.

In co-operation with Professor Whitney of the Division of Soils, United States Department of Agriculture, this department installed one of his instruments (kindly loaned by the Department at Washington) for the electrical determination of moisture in the soil. Observations were taken from the latter part of June until early in November. The records, however, are incomplete for the period, owing to breaks in the circuit and other causes which made the instruments fail to work at times. The readings taken were sent weekly to the Department at Washington. The Division of Foods and Feeding of this station made some

independent determinations of moisture for standardizing the instrument, and the Division of Botany kept a record of the growth of the crops where the electrodes were buried. Owing to the unusually wet weather during the summer and the incomplete records of the instrument, the results of the experiment were not entirely satisfactory. The department expects to repeat the observations next year under more favorable conditions, and an outfit for that purpose has been ordered.

It is hoped that arrangements may be made to put the electrometer in the tower in working order, so that observations on atmospheric electricity may be undertaken.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Our work during the past year has been in general a continuation of that of the year preceding. In this, as in other departments of the station, the work falls under two classes: first, examination of material sent in for determination and answering of inquiries; second, investigations of problems connected with plant physiology and pathology.

For the purpose of investigation the greenhouse has been remodelled and enlarged during the past summer, so as to admit of carrying on experiments under more desirable conditions. It is quite essential, in experimenting with plants, that the number employed should be large enough to make it possible to draw deductions from the results with a reasonable degree of certainty that errors arising from individual variation have been counterbalanced. It is also essential that the heat, light and moisture conditions should be equal upon each series of plants under consideration, and that these conditions should compare as closely as possible with the best method of cultivation. In the construction of the experiment house these details have been considered as carefully as possible. The house as now arranged consists of several sections, in which different temperatures can be maintained, for growing tomatoes, cucumbers, lettuce and other important plants subject to destructive diseases. The amount of money invested in the production of greenhouse crops is large and continually increasing, and no small part of our work consists in the study of the various diseases which affect them.

For the last three years we have been investigating methods of controlling the gall-forming nematode worm, which affects cucumbers, tomatoes, English violets, roses, cyclam-

ens and many other greenhouse plants. The results of the investigation are nearly ready for publication, but it seems desirable to first clear up a few remaining points upon the habits of the worm, which are not well known.

Experiments are also being made upon the different methods of pruning tomatoes, and upon the best light conditions for assimilation in greenhouse cucumbers.

With regard to lettuce we are studying the mechanical conditions of the soil as affecting the crop, and the various fungous diseases to which it is subject, more especially the disease known as the "drop."

In addition to these experiments, it may be mentioned that there are incidentally being carried on investigations upon the influence of electrical currents on the growth of plants. Bulletin 43 of this station embodied the most careful and extensive series of experiments ever made upon the subject. They were carried out by Mr. Asa S. Kinney, while a student at the college, and did not necessarily fall under station work. The results obtained by him were of such a promising nature that it has seemed well worth our time to carry the investigation further. It should be stated that any costly method of using electricity as an accelerator of plant development is not to be recommended. If, however, any simple and cheap means of using electric currents can be used, which will give an acceleration in the growth of a crop equal to 30–40 per cent., it might be worthy of consideration by practical agriculturists.

We have in progress a series of experiments with various gaseous substances, with a view to developing a treatment of this sort for combating fungous diseases of greenhouse plants. This method of treatment has been suggested by the extensive application which it has reached in exterminating insects. While we are as yet unable to present any results of great practical value, it is hoped that these experiments may lead to the development of an effective treatment for greenhouse plant diseases by the use of a gaseous substance. The great superiority of such method over that of spraying, which is in many cases inapplicable, needs no exposition. Our experiments thus far have been carried on

with two gases, hydrocyanic and formaldehyde. Neither of these appears to answer the purpose. The former, which has been found to be of considerable value as an insecticide, cannot be made effective as a fungicide without using a strength which will prove fatal to the plant. This we have determined by parallel exposures of various fungous spores and plants to the gas, and also by the fact that spores of the carnation rust, taken from plants which had been almost killed by over-exposure, germinated freely. Formaldehyde has a well-marked fungicidal effect, and is much less harmful to plants; but we cannot at present recommend it as a general fungicide, on account of the difficulty of producing it in sufficient strength.

The past year has been an exceedingly abnormal one for vegetation, and as a result this division has had many inquiries concerning plant diseases, different from those of ordinary years. The excessive and long-protracted rains and the lack of sunshine gave rise to a multiplicity of plant diseases such as we have not had for some years. This was the case not only in regard to our various crop plants, but our introduced ornamental species and even our wild plants were unusually affected by fungi. An unusual number of the so-called spot diseases made their appearance, and defoliated to a greater or less extent more than one species of tree. These spot diseases were especially disastrous to the sycamore and butternut, both of which in many instances lost all their foliage; while other trees, such as the chestnut and wild cherry, were more or less affected. The fungi causing these diseases are not new to these trees in this locality, but the abnormal conditions to which all vegetation was subjected proved amply sufficient to accelerate their growth and development.

Whenever the normal conditions surrounding the plant are disturbed, we must expect to find irregularities in its functions; and any serious irregularities in the plant's functions are most likely to manifest themselves by the presence of some insect, fungous or bacterial organism. Abnormal functions, or, in other words, physiological disorders, are in a majority of instances the basis of many plant diseases

with which gardeners have to contend; and, since we are liable to observe only the effects of the fungus or bacteria preying upon the plant, we too often think that they are the primary causes of the disease, when, as a matter of fact, they are purely secondary.

This leads us to the subject of spraying as a preventive of plant diseases. From the hap-hazard manner in which it is often resorted to, one would gain the idea that it is intended as a curative rather than as a preventive remedy. This idea is erroneous, inasmuch as spraying is intended as a prevention rather than a cure. This misconception of the proper use of spraying solutions gives rise to the practice of using the Bordeaux mixture as a panacea for every plant disease. Upon this point we wish to state that it must be distinctly borne in mind that spraying under any condition is only a temporary means of preventing certain diseases. The ultimate aim of all progress connected with gardening should be not only to improve the marketable product, but to improve the stock and increase our knowledge pertaining to proper cultivation, so that spraying will be unnecessary. Many experienced gardeners recognize this, and we find experts in almost every line of gardening who have had eminent success in controlling diseases without resorting to the use of fungicides. Some of the most experienced growers of carnations claim that they can control the many diseases which have of late years affected this plant, by simple, judicious methods in the management of the greenhouse.

To expect that spraying is going to save plants that are improperly cared for, or to act as a cure for those already diseased, is absurd. There are many instances where spraying produces beneficial results, and at the present time it appears to be essential, in some instances, to the production of good crops; but there are also many instances where it is entirely useless. This applies especially to the diseases having their origin in improper care or in abnormal conditions surrounding the plant. The condition of the potato crop in Massachusetts during the past summer affords an illustration of how any amount of spraying would not save

it from disease, when the soil was soaked with water and the plants in some instances practically submerged for days at a time. Every plant is surrounded by a host of parasitic organisms, which, given the proper conditions, will manifest their distinctive properties. The healthy, vigorous plant is always less susceptible to the attacks of fungi than the weakly, abnormally developed one, — a fact which every practical gardener readily understands. We have seen this illustrated so many times in our work in the greenhouse that it may be well to give an example of it here. Certain species of non-parasitic nematode worms, which are always present in greenhouse soil, although apparently doing no harm as long as the plants are vigorous, will, as soon as the plant becomes weakened or abnormal from any cause, penetrate the tissues and cause rapid decomposition of the same. What is true in regard to nematodes applies also to fungi and bacteria, and, indeed, these various forms of organisms are most frequently to be found together in the decayed tissues of the plant.

Before any attempt is made to spray diseased plants, it is well worth while to find out something about the nature of the disease with which the plants are affected. It is, for example, unwise to spray roses for the black spot or mildew when the roots are half decayed by the action of parasitic gall-forming nematode worms; and for the same reason it would be unwise to treat the spot disease of the English violet, when the roots are covered with hundreds of minute galls, and when the supply of nutriment from the root is greatly interfered with.

On the other hand, spraying the apple, grape, potato and plum is at the present time justifiable and necessary; and there are many diseases common to greenhouse cucumbers and tomatoes which can be largely controlled by spraying, although it must be said here that by judicious management of the various conditions surrounding the plants these diseases can be checked.

THE CAUSES OF THE FAILURE OF THE POTATO CROP OF 1897.

The disastrous effect upon agricultural crops of the excessive rainfall of the past season has been especially marked upon the potato. The small yield and large amount of rotting of this staple may be easily attributed to this source. In all sections of the State, as well as beyond our borders, the report has been general of a small potato crop and excessive rotting. This rotting has been generally regarded as resulting from the well-known and ordinary "potato rot" fungus, Phytophthora infestans. In fact, however, we have to describe a series and variety of agents, which, under the favorable influence of the excessive rainfall, — an influence unfavorable to the vitality of the plant, — have brought about the diminution and destruction of the crop.

At planting time the ground was extremely wet. The crop, however, started well, and the plants appeared above ground in a promising manner. Continuous rains kept the soil saturated with moisture, and before the plants had reached a height of more than six inches it was noticed in many places — usually the lowest and wettest portions of the field — that many of them were dying. Such plants did not collapse suddenly, but gradually turned yellow and faded away, most of them dying eventually, though here and there one would be seen which maintained a feeble, stunted growth through the season. This was the case not only in this vicinity, but it was also reported from various parts of the State.

Investigation of affected plants showed that the trouble was due to a rotting of the stem of the young plant below ground, which rotting evidently proceeded from the seed potato, which was found in every case to be a putrid mass, while the decay was gradually extending up the young stem. Careful search for the cause of the rotting failed to reveal any particular organism to which it could be ascribed. That it was of bacterial origin seemed quite certain, as the decayed tissue swarmed with organisms of this class, while no fungus which could be considered the cause of the rotting

was found. In the cortex and exterior portions of decayed stems several forms of Micrococcus and also other bacteria were found in abundance. In the interior portions a large, motionless bacillus occurred quite abundantly and exclusively, and may have been the primary cause of the rotting. The most probable explanation, however, seems to be that the normal functions of the plant were disturbed and its growth checked by the unusual amount of moisture in the soil. The seed potato, with its supply of reserve food material for the young plant thus left idle in the soil, naturally rotted away, and this rotting communicated itself more or less to the young stem proceeding from the "seed." The plant, not being in a condition of vigorous growth to resist this rotting, gradually succumbed to it, and in most cases died. The few plants, as mentioned above, which continued a feeble growth through the season, accomplished this by throwing out roots above the rotted portion of the stem, and thus prolonged a feeble existence. Such plants produced no tubers, and consequently had no value whatever.

This, then, was the first of the troubles affecting the potato crop in this section. We do not describe or consider it as a specific "disease" of the potato, nor do we deem it necessary to consider any treatment for it. We at first recommended removing affected plants, but doubt now if such a course would have been of any considerable practical value. We are inclined to believe that the trouble was not brought about by any specific or especially destructive organism, but was simply the result of the unusual meteorological conditions of the season, and under such conditions could not be prevented from occurring by any means at our command.

By July 1, most of the plants which had fallen a prey to the above disease were withered away and dead, while those which had escaped had made a fairly good growth and nearly reached maturity in point of size. About July 15 several hot, sunny days came on, following a long very rainy spell. In many potato fields on low ground the plants began to wilt and die down. In a large field at the college, situated on a long slope, the plants at the top were un-

affected, but those in a limited area at the bottom of the slope — the wettest part of the field — began to wilt (see plate). Many had already died here from the effects of the first disease. It is a well-known fact that plants often wilt when exposed to strong sunlight after a continued cloudy and wet period, this being due to excessive evaporation or transpiration of water from the leaves. In this case, however, the wilting was too pronounced to be attributed to this simple physiological phenomenon. Investigation showed that the leaves were not "blighted" nor were they affected in any way except the simple wilting, which was evidently caused by some trouble at the root. Plants were then dug in various portions of the affected area, and in all stages of collapse, and their roots examined for the cause of the trouble. It was found that there was no one organism (except possibly bacteria) attacking the plant, but there was a general rotting, resulting from the wet condition of the soil and consequent low vitality of the plant. The features of this rotting varied greatly in different plants, however, and scarcely any two were affected in an exactly similar manner, it being almost impossible to specify a feature of the disease common to all, except the wilting of the tops. In the very wettest part of the affected area the tubers were rotting badly. These rotten tubers were swarming with bacteria, but they were of various kinds, and to no one could be ascribed the beginning of the trouble. Various species of fungi were found in some, but these were moulds and similar forms, and included nothing which by any probability could have caused the rotting. Since fungi were entirely absent in many of the rotten tubers, it is certain that they did not cause the trouble. In many cases the decay seemed to have started where a grub of some kind had eaten into the potato. On somewhat dryer ground, where the plants wilted, the tubers were not rotten. In many cases, however, the stem was found to be decayed just where it joins the root. The young rootlets were also rotting, so that the cortex fell away from the central portion. These symptoms also occurred, and more pronouncedly, in cases where the tubers were rotten. In

these decayed stems and roots no one organism could be found as the cause of the rotting. Bacteria (mostly micrococcus) swarmed in all affected parts, and several mould fungi also occurred. Quite noticeable on all affected plants was the occurrence on tubers and even on the base of the stem, of small, white, mealy dots, scattered abundantly over the surface. These were apparently enlarged lenticels, being composed of parenchymal cells breaking out at the surface. It seems probable, or is at least possible, that their production was due to the scarcity of air in the wet soil.

We can only conclude here, as in the other case, that this cannot be called a definite disease, but rather was the result of abnormal and unusual conditions. During the long-continued rain the living functions of the plant were disturbed and its growth checked. Various organisms then came in, and, gaining a foothold, so weakened it that when the sun came out it wilted down and in the worst cases died. Had it been possible to thoroughly cultivate and stir the soil at this time, it is reasonable to suppose that much of the trouble might have been averted; but the extreme wetness made such a course impossible.

This trouble came on after the potatoes had reached a marketable size. We therefore recommended digging them in all affected places, in order to save them from decay. Beyond this there could be no practical treatment suggested.

Early in August, or even sooner, the real potato blight or rot, Phytophthora infestans, began to appear, and developed very extensively during the month, killing the tops of potatoes everywhere, and causing great loss by rotting of the tubers. This disease is too well known to need extended description. Its ravages might probably have been controlled to some extent by thorough spraying throughout the season, but it would have been practically impossible to entirely prevent it in such a summer.

The "Drop" of Lettuce.

The loss represented by this disease frequently amounts to thousands of dollars in a single season in Massachusetts. Almost every lettuce grower has had more or less experi-

ence with it, although, as with every other disease, some have been much more affected than others. We have known several instances during the season where extensive growers have lost practically their whole crop, and, as a consequence, have become much discouraged with lettuce growing. Inasmuch as the general characteristics of this disease were given in the ninth annual report, it is not necessary to enter upon any minute description here. Suffice it to say that the disease makes its appearance in the stem, close to the surface of the ground, where the tissue becomes slimy and soft, and eventually the whole stem at this point disintegrates and collapses. This occurs most frequently just as the plants reach maturity.

The fungus causing this disease is well known to all greenhouse men. The "damping fungus" (Botrytis), which causes the drop, often gives rise to disastrous effects on begonia and other cuttings in the propagating pit. The fungus, however, as it appears upon the lettuce, presents some aspects which are different from its appearance upon cuttings, and reaches a more advanced stage of development. Our present knowledge in this direction possesses more of a technical than practical interest, although an understanding of the complete life history of the fungus will, no doubt, lend much aid to its rational treatment.

The natural conditions governing the development of the organism appear to be similar to those of most organisms, — that is, it requires the presence of oxygen. It is well known that almost any object when driven into the ground will undergo disintegration much more rapidly at the surface of the soil, for here the conditions of moisture, etc., are most favorable for the organisms producing disintegration. And so it is with the "drop" fungus; it finds just the conditions at the surface of the soil, under the moist, shady leaves of the mature lettuce plants, for its destructive work.

Our experiments upon the control of this fungus are by no means complete, but it will not be out of place here to offer some suggestions in regard to its general habits and the methods of treatment which may be tried. Probably

every grower has the germs of the disease in his lettuce soil to a greater or less extent, but the conditions giving rise to their excessive development are not always present. Some claim that manure is the principal source of infection; yet, on the other hand, while all use manure, all are not troubled in the same degree. As a remedy for the drop, some have resorted to the practice of sanding the surface of the soil or putting on a layer of yellow loam. This is for the purpose of giving a clean, uninfested surface to the soil surrounding the plants. In regard to the effect of this treatment, it may be stated that opinions differ considerably. Whether the method of applying a superficial layer of sand or subsoil to the surface will be of any assistance in keeping the drop in check appears somewhat doubtful, from an experiment made of burying some infested plants to a depth of three or four inches in a pot of yellow loam subsoil. It was found that the fungus made its way to the top in a very few days, as was evident from the mould-like growth of the mycelium upon the surface of the soil and the death by drop of plants which had been set in the pot. Neither can we expect much from the application of chemicals, as any such treatment would interfere with the growth of the plant, and hence become objectionable. Some experiments are now being made with gases, with the idea of killing the organism by fumigation; but this method does not promise much success.

The application of live steam to the soil, and thus sterilizing it, would undoubtedly destroy the germs of the disease. To do this would necessitate laying two-inch tile at a depth of eight inches or a foot below the surface of the soil, and at a distance of one or two feet apart, and driving in steam under pressure and allowing the same to permeate the soil. This method can be employed on a small scale with good results, but the larger area of a lettuce house would render its practical application uncertain. Another method of treatment by steam, which would be far cheaper, would be to sterilize the surface of the soil to a depth of three or four inches or more. This can be done by constructing a pit in the lettuce house and covering the bottom

with tile or one and one-half or two inch steam piping. The tile allows the steam to escape very readily; and, in order to get the best effect, they should be laid close together, say one foot, or less. In case steam pipes are used, — and they are probably more effective than tile, — they should be bored with holes every three or four inches, to allow the steam to escape. With an arrangement of this kind, one would be able to sterilize the soil in a few hours. A pit twenty feet long, ten feet wide and eighteen inches deep would hold sufficient soil to cover twelve hundred square feet of surface three inches deep. The time required to heat this earth up to 200° F. would be only a few hours. Of course the pressure of steam available, the closeness of the pipes and the number of outlets for the steam would largely determine the time necessary to heat the earth.

Various methods of treatment for this disease are being tried, to determine how it may be most effectually dealt with. In connection with the method of steam sterilization, which seems by far the most promising, it is especially desirable to ascertain just how deep the soil must be sterilized in order to keep down the fungus.

The Asparagus Rust.

(*Puccinia asparagi.* D. C.)

In the last annual report of this division attention was called to a new disease which had appeared upon the asparagus, and the apprehension expressed that it might come to be a serious matter. That apprehension has been more than justified. The asparagus rust, unknown to the growers of Massachusetts in 1895, slightly prevalent in 1896, has appeared everywhere during the past season, and bids fair to become a most important factor in the growing of this crop.

The disease first appeared in the fall of 1896, both in this State and in several others, but was not generally prevalent at that time, although in some fields it was very abundant. Cutting and burning infested tops was generally recommended and to some extent practiced; but the majority of asparagus growers had not as yet become acquainted with this new danger menacing their crops.

This rust, like the well-known one of the wheat, has three different stages or forms in its development, though in this case they are all developed upon the asparagus plant, while in the other, one form comes upon the barberry bush and the other two upon the wheat and other grains and grasses. When first noticed in 1896, the asparagus rust was in the fall stage, the black rust or *teleuto* stage, the earlier stages not having attracted attention. In 1897 many asparagus fields were found to be affected as early as July 1, and by August the complaint was general throughout the asparagus-growing sections of the State. It was now the red rust, or *uredo* form, which was present, being followed again in the fall by the black form. Apparently almost every field of asparagus in the State was affected before the end of the season. The rust in most cases appeared first on young beds, — which was natural to expect, since the stalks were not being continually cut off as they appeared. In the older beds, from which the stalks were being cut for market, little or no rust appeared until well into July or August, after cutting had been suspended and the tops allowed to develop. In most cases, however, they were soon affected as badly as any. The effect of the rusting was that the tops lost their green color, and turned brown and died prematurely. Mr. George P. Davis of Bedford says in regard to his beds: "The twenty-sixth of July the tops were all turned brown, and looked as though a fire had swept over the field. There was no green to be seen. . . . In handling the tops a fine dust which looked like smoke was quite noticeable." This dust consisted of countless numbers of the spores of the fungus.

The first attempts at checking the rust were made in the fall of 1896, and consisted of cutting and burning affected tops. When the disease appeared so extensively in 1897, many growers cut the tops in August, when they had become badly rusted. It is impossible to say with much certainty what the result of the first cutting (fall of 1896) may have been, inasmuch as comparatively few beds were thus treated or badly affected at that time. A good-sized bed at the college was considerably rusted, and the tops

were cut and burned late in the fall. The bed was well cultivated and fertilized, and no rust appeared upon it in 1897 (that is, not enough to be noticeable) until well into the fall, when the black rust stage was quite as abundant as it had been in 1896. Mr. S. T. Davis of Orleans also mentions having observed a small bed, which was cut in the fall of 1896, upon which no rust appeared in 1897. Whether the cutting of the tops or some other factor kept down the rust in these beds, we are not prepared to say. The cutting which was quite extensively practiced in the summer of 1897 seems to have been entirely without effect, as the rust appeared again just as badly on the second growth.

The experience of another season is necessary to demonstrate the actual effect and seriousness of this disease. Its perennial occurrence to the extent of the past season could not fail to have a disastrous effect upon the asparagus-growing industry. It is not the sort of disease which is effectually suppressed by spraying methods, though something of that sort may be developed if it becomes necessary.* It should be remembered, however, that the past season was an unusually favorable one for all fungous diseases, and consequently it may have developed much more extensively than it ordinarily would. If it could be mostly confined to its teleuto or black rust stage, which appears in the fall when the plants have practically completed their growth, it is not probable that any serious injury would result. At all events, the effect of the great prevalence of the rust in 1897 upon the asparagus crop of 1898 will be awaited with great interest by all interested in its cultivation.

The Fire Blight.

(*Micrococcus amylovirus.*)

This disease of the pear, quince, apple and other pomaceous trees has been the subject of frequent inquiry during the past season. It ordinarily causes the most damage on the pear and quince, and is one of the most destructive of plant

* Recent experiments indicate some amenability of the rust to spraying, although not more than twenty-five per cent. reduction is claimed.

diseases. The trouble appears in the branches, sometimes a whole limb of considerable size, but more often the smaller terminal twigs, being affected. These portions of the tree suddenly wilt and die, the leaves and young fruit turning black and hanging to the branches, producing the characteristic scorched appearance which gives the disease its name. It spreads rapidly about an orchard and increases from year to year, often involving the entire tree and causing its death if left unrestricted.

The cause of this trouble was long a matter of speculation, but it is now known to be a species of bacteria which gains access to the tissues of the tree and by its rapid multiplication therein causes great destruction. This disease cannot be reached by spraying, and the only remedy consists in severely cutting back all affected branches, or whole trees if badly affected. All such prunings should then be destroyed by burning. This cutting should be done whenever the disease is observed, but is especially advisable in the fall or late summer, when the trees should be carefully examined, to make sure that no diseased branches or twigs are left to perpetuate the disease over winter. As the disease affects the hawthorne (Cratægus), shad bush (Amelanchier) and mountain ash (Pirus Americana), as well as the cultivated fruits, it may spread from some of these wild trees to the latter, unless care is taken to prevent such contagion. It is not probable, however, that such infection is ordinarily at all extensive.

The Quince Rust.

(*Gymnosporangium clavipes* C. and P.)

The numerous inquiries which we have received during the past season concerning this not uncommon trouble, as well as our own observations, indicate that it has been unusually prevalent and destructive. The disease affects principally the fruit, but also the young wood, causing distortion and malformation in both cases. It is very conspicuous upon the affected quinces in midsummer, both from their distorted shape, and from the numerous white, tubular excrescences appearing upon their surface. These excres-

cences contain masses of the bright orange-yellow colored spores of the fungus which causes the disease. The fungus has a peculiar course of development. It not only exists in the form seen upon the quince, but has also another form or stage, living upon a different kind of plant and quite different in appearance. This stage of the fungus lives upon the red and white cedar and the juniper, and is one of the forms which produce upon those plants the abnormal growths popularly known as "cedar apples." These cedar apples are peculiar outgrowths upon the twigs of cedars and junipers, reaching their complete development in early spring. They are oftentimes regarded as the proper product of the tree, or as insect galls, — which ideas are equally incorrect. These growths begin to form in midsummer, developing as small excrescences upon the twigs and gradually increasing in size until winter, when they are nearly full grown. An "apple" consists at this stage of an abnormal mass of the cells of the tree, with the filaments of the fungus growing abundantly between them. Remaining thus over winter, the first warm, moist weather of spring starts it into further growth and development. Upon the surface of the affected wood numerous projections appear, of a conical shape, and composed of a yellow, gelatinous substance. These projections are composed of a mass of the fungous filaments and a gelatinous substance which they secrete. In them are produced the spores of this, the *teleuto* stage. These spores are composed of two cells and borne on long stalks. The sudden appearance of these peculiar growths on cedar trees just after a spring rain is often taken for the blossoming of the tree, but is in reality the fructification of the fungus parasitic upon it. The gelatinous appendages of the cedar "apples" soon dry up and wither away after the rain, but not until the teleuto spores contained in them have germinated and produced secondary reproductive bodies called *sporidia*. These are carried away in the air, and proceed to infect, not cedar trees, but quinces or one or two other related plants. Upon the surface of these they germinate and produce filaments which grow into the substance of the young fruit or stems, and by their presence there cause the

distortion in shape seen in affected specimens. Upon this host the fungus forms little pustules just beneath the surface, finally breaking out into the air as tubular projections. In these are formed the yellow spores of this stage, called *æcidia*. These spores are unable to infest quinces again, but upon cedar trees begin the development of a new generation of "apples," which will in turn produce teleuto spores the following spring.

Treatment. — It is not often that the damage caused by this disease is of great extent. Sometimes, however, it becomes sufficiently troublesome to make it worth while to attempt to repress it. It is evident that the most vulnerable point of the fungus causing the trouble lies in its inability to reproduce itself continuously upon the quince. The most direct method of treatment, therefore, is to exterminate all white and red cedars and junipers from the vicinity of the orchard, and cut off all affected parts of the fruit trees, or entirely destroy badly affected ones. This, for various reasons, however, may not always be possible or desirable. As to spraying methods, it has been found quite effective to spray with Bordeaux mixture two or three times during the spring, especially during or just after rainy weather, when the spores are being disseminated. It may also be possible sometimes to remove affected twigs of cedar and juniper trees before the spores have been produced.

This same fungus has also been unusually abundant during the past season upon the fruit of various species of Cratægus (hawthorne), accompanied by an equal abundance of the closely related species, Gymnosporangium globosum, upon the leaves. We have also noticed these or related species upon the fruit of the Japanese quince (Cydonia Japonica) and mountain ash (Pirus Americana).

The Brown Rot of Stone Fruits.

(*Monilia fructigena.* Pers.)

This well-known disease found in the past summer just the conditions suited to its best development, and the peach, plum and cherry crops suffered in consequence. The dis-

ease needs no description to those who have ever tried to raise any of the above-mentioned fruits. It appears in the summer, some time after the fruit has set, often just as it comes to maturity, or even earlier in the season, the time of its appearance depending a great deal upon the weather, a warm, rainy period being liable to bring it on at any time. Indeed, it does not always wait for the production of fruit upon which to make its attacks, but often develops upon the blossoms, causing them to abort, and spreading thence into the young twigs upon which they are borne, results in their death. Upon the fruit the rotting is almost always found to some extent at the time of ripening, and, as already mentioned, often occurs earlier in the season when the weather is favorable, i. e., warm and moist. At such times the greater part of the crop is sometimes destroyed. In cherries the chief damage is done upon the ripe fruit. In peaches and plums, which have a longer season of ripening, the young fruit is more frequently affected. Early peaches are considered more susceptible to the disease than the later varieties.

The cause of this disease is a mould-like fungus (a true parasite, nevertheless), which spreads its vegetative filaments through the affected fruit and thus causes its decay. Wet weather brings about the rotting of the fruit by favoring the growth of the fungus, not by its direct effect. Fruit which is affected begins to discolor and soften, and gradually dries up and shrivels into a shrunken mass about the stone. It often remains on the tree for months, especially in the peach. In the early stages of infection the surface becomes covered over with little grayish spots of a powdery, dusty nature. These are clusters of the spores of the fungus, produced in countless numbers on the ends of filaments from the inside of the fruit which have pushed out through the surface. These spores, which serve to reproduce the fungus, are extremely minute in size, so that *en masse* they appear as a fine dust. Being easily carried by the wind, they are spread far and wide, and may thus infect a large district in a few days, under favorable conditions. After becoming dry and hard the affected fruits cease producing

spores, but their period of harmfulness is not yet ended. After lying over winter in a dormant state, the fungus in them is again aroused to life by the warm rains of spring, and begins the production of spores which are ready to infect the crop about to be produced.

It has been thought practicable by some to exterminate or at least greatly reduce this disease by the destruction of all affected fruit and thus prevent the fungus from surviving through the winter. The variety of fruits upon which it can exist, however, and the practical hopelessness of accomplishing the destruction of any considerable proportion of it, together with the uncertainty of the fungus being altogether dependent upon the dormant stage found in the dried-up fruit for its existence over winter, make the success of this plan very doubtful. We would not, however, discourage the practice of removing and destroying the affected fruit, especially any remaining upon the trees over winter; for this may result in future decrease of the rotting, especially in isolated orchards or trees.

The usual methods of orchard spraying have been found to keep this disease in check to a considerable extent, though in favorable weather it will often sweep through an orchard, despite all precautions. The spraying should be begun early, and kept up through the season with considerable frequency, especially near the time when the fruit is maturing. For such spraying, Professor Maynard recommends the use of the ammoniacal copper carbonate or a weak solution of copper sulphate. Details in regard to the treatment of this disease may be found in Bulletin 44 of this station.

The Chrysanthemum Rust.

(*Puccinia Tanaceti*, S.)

In the last annual report a rust upon chrysanthemum leaves was described, this being, as far as known, the first published mention of such a disease. The specimens were sent by Mr. G. H. Hastings of Fitchburg, who had experienced heavy loss as the result of the rust. This was the only occurrence of the disease encountered during 1896.

This year it has appeared in many places, both in this and other States, occasioning considerable loss, as it is often very destructive to infected plants. It is not yet generally known, however, among those who cultivate the chrysanthemum, though we fear that it may be by another year. Judging from the history of many similar diseases (asparagus rust, carnation rust, hollyhock rust, etc.), it will not be surprising if a general epidemic of this disease occurs next year. It will be well worth while, therefore, for growers to take precautions for guarding against it as much as possible, especially those whose stock is already infected. Great care should be exercised to get cuttings from vigorous plants, unaffected by the rust; and it will no doubt be profitable in the end to spray them a few times during the summer with the Bordeaux mixture or potassium sulphide, using one ounce of the latter in two gallons of water, or stronger, if the leaves will stand it. Should the rust appear on the young plants, they should certainly be sprayed at once and at frequent intervals thereafter, and the affected plants removed and destroyed. It will be useless to try to save them as they are doomed to destruction, or at best will only attain a weak, sickly, worthless growth. When the plants are placed in the benches for the fall, great care should be taken that no rusty specimen goes in, else it may bring about the ruin of the entire lot. Further than these suggestions little more can be said about the disease until time shall have shown what its seriousness may be and to what extent it can be controlled.

There are several other diseases affecting the leaves of the chrysanthemum, so that some may be in doubt whether their plants are really infested with the rust. It causes discoloration of the leaves, like other less destructive diseases, but may be distinguished from them by its production of small pustules, of a dark-red, powdery substance, on the under side of the leaves, something as in the carnation rust. This red powder consists of the spores of the fungus, which reproduce and disseminate it.

A Disease of the Cultivated Geranium.

During the past summer there appeared upon the leaves of some geranium plants upon the college grounds a disease which appears to be different from anything heretofore described. The plants in question grew in a long border bed, and comprised several different varieties. Along the back edge of the bed, trees and low shrubbery hung over to a considerable extent, so that the plants in that portion were quite shaded, while those in front were exposed more directly to the sun. The disease came on in the latter part of July, during the rainy weather then prevailing. The leaves began to turn yellow in small spots, which gradually increased in size, the leaf tissue dying away at those points; thus the leaves soon became covered with dead spots of considerable size, and finally lost their vitality completely. The plants in the front of the bed were most affected, those in the shaded portion showing little or none of the disease. All varieties, as above mentioned, were equally affected. The plants were sprayed with the Bordeaux mixture, but with no apparent success. The same disease was brought to our notice in Northampton and also in the eastern part of the State.

The trouble appeared to be the result of the attack of some fungus, but investigation of the affected leaves failed to reveal any such organism. Neither was there any evidence of the presence of insects. Numerous bacteria, however, were found in all affected tissue, and appeared to be the cause of the spotting of the leaves. We do not consider this a genuine disease of the geranium, nor do we expect to find it occurring in the future. That the plants were in a condition of low vitality and hindered growth by reason of the excessive moisture, and hence were an easy prey to organisms which ordinarily would be unable to affect them, seems the most probable explanation. The futility of spraying to prevent such a disease becomes apparent when its real nature is revealed.

Some Leaf Blights of Native Trees.

During the past season several different kinds of trees have been so generally affected with certain leaf-attacking fungi as to become almost entirely defoliated before the end

of the summer. While of no great economic or practical importance, these attacks have been so marked and their effects so conspicuous that a brief description of the nature of the trouble may be of interest. The following diseases were generally prevalent wherever the host trees occurred, over the considerable portion of New England which we visited during the summer.

A Leaf Blight of the Sycamore or Buttonwood.

(*Glocosporium nervisequum* Fckl. Sacc.)

Numerous inquiries reached us during the spring and early summer concerning the very prevalent and destructive blighting of the leaves of the sycamore tree (*Platanus occidentalis*). It is probable that every good-sized tree of this species in the State was attacked by the disease. The younger trees were apparently, for some unexplained reason, less susceptible. The trouble appeared in May, when the trees, which had just leaved out, appeared as if they had been nipped by a frost or scorched by fire. The leaves withered and turned brown, the new twigs were killed and many of the leaves fell to the ground. In this condition the trees lost all beauty, and became unsightly objects. This disease is not entirely new in this State, although it has never been so generally prevalent before. It was first described in Germany in 1848, and has been common in various parts of Europe since then. In this country it has occurred mostly within the last fifteen years. It first appeared in the District of Columbia, Ohio, Kentucky and other parts of the country south of here, but is now widespread.

The cause of this disease is a parasitic fungus, growing in the leaves and young twigs of the tree, and causing their death. Several other fungi are usually found in connection with the disease, and may have something to do in causing it. This disease is a very serious drain upon the vitality of the tree, and often results in its death. Its occurrence early in the season, however, favors the tree, since it has a chance to, and in fact does, produce a new crop of foliage to carry it through the season. This exhausts the tree, however, and if repeated for several seasons is likely to cause its death.

As to a remedy for this disease, there is little to say. Spraying with fungicides is not to be practically considered, on account of the size and small economic importance of the tree. Gathering and burning diseased branches and leaves might lessen the trouble somewhat; but, if the disease continues to prevail, it will probably be best in the end to dispense with the sycamore as an ornamental tree, and plant something else instead.

A Leaf Blight of the Butternut.

(*Gloeosporium Juglandis* (Lib.) Mont.)

No fungous disease has been more noticeable throughout the State during the past season than this. It first became apparent in July, when butternut trees were noticed to be losing their foliage. Examination showed that the rapidly falling leaflets were covered with dead and discolored spots, and had lost their vitality. All trees were not affected in the same degree, as some were almost completely defoliated in August, while others were attacked later or lost their leaves more slowly. By October 1, however, it was almost or quite impossible to find a butternut tree which had not lost the greater part of its leaves.

The cause of the trouble is a fungus, which lives in spots in the leaf, killing the tissue at these points and gradually causing the death of the whole leaflet, so that it falls to the ground. The disease spreads rapidly from leaf to leaf and from tree to tree, and many trees are soon defoliated. It is a well-known fungus, but has been unusually abundant this year.

A Leaf Spot of the Chestnut.

(*Septoria ochroleuca* (B. and C.)

This is another disease, quite similar to those above described, which has been very prevalent this year. It first became noticeable in July, when the ground under chestnut trees was covered with fallen leaves. Upon these leaves the fungus manifested itself very prominently in small, round, dead spots, about one-eighth of an inch in diameter, scattered over the surface more or less abundantly. These spots are the points where the fungus has become estab-

lished and killed the tissue. The fungus, like all those causing these diseases, reproduces itself by spores, which are produced in minute cavities in the dead area, usually on the under side of the leaf. Almost all the leaves on affected trees become dotted over with the little dead spots, and most of them fall to the ground before their time, thus weakening the tree. The disease is not, however, an especially destructive one, except to the beauty of the tree.

A Leaf Spot of the Wild Black Cherry.

(*Septoria cerasina*, Pk.)

The well-known "shot-hole" fungus, which often causes extensive damage to the plum and cherry, has been exceedingly abundant this year upon the leaves of the wild black cherry (*Prunus serotina*), many trees being almost entirely leafless in August. This fungus attacks the leaves of plums and cherries of several species, producing dead spots upon them, and eventually causing their death. In connection with the wild cherry the disease has little economic importance, except as it may spread from that tree to cultivated species. On this account, the destruction of the wild cherry, so desirable for the repression of the black knot and tent caterpillar, is even more advisable.

BACTERIAL BLIGHT OF GERANIUM

QUINCE.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of work in this division the past season have been largely the same as for 1896.

Raspberry Seedlings.

The collection of raspberry seedlings, now three years old, produced a large crop of fruit the past season, and many most promising varieties were found among them. These seedlings were from the hybrid or purple-cap variety *Shaffer*. They produced a great variety of forms, from the black-cap type (*Rubus occidentalis*), the hybrid type of the parent, to some of the most beautiful forms of the red raspberry (*Rubus strigosus*) and to albino forms of both species. Careful records of the hardiness of cane, vigor of growth, time of ripening, productiveness and quality were made during the season, and at this time the plantation is a very handsome one.

Another collection of seedlings from the same source, but one year younger, also shows many interesting forms of growth.

Seedling Currants.

About three hundred seedling currant bushes two years old have made a good growth and show many interesting varieties.

Grape Seedlings.

The collection of seedling grapes, numbering some six hundred varieties, is very interesting. The growth has been very vigorous and healthy, and most of them are in a condition to yield enough fruit next season to determine some-

thing of their value. From the appearance of the foliage and the growth of vine we may look for a great variety of types of fruit.

Strawberry Seedlings.

This collection, numbering about four hundred varieties, is in a very fine condition, and some varieties have shown decided merits.

Named Kinds of Strawberries.

Many new varieties of strawberries of decided merit have been added to the collection. Many of the older varieties of little merit have been discarded, and the plots at this time never looked so well.

Strawberry Field.

The field crop is planted on the knoll south of the old farm buildings, and is in a remarkably good condition. This land is of a gravelly nature, but with a retentive subsoil of hardpan, which in an ordinarily moist season may be depended upon to produce a large crop of fruit, but in a very dry time suffers severely. The land slopes in such a manner that either the trench system or the spraying systems of irrigation or sub-irrigation can be employed in case of drought. Two reservoirs on the grounds are available for this purpose, and the three methods may be comparatively tested. A considerable quantity of two and one-half and two inch pipe on hand is available for this work. This need not be of any great expense, while its importance is very great, as no comparative results have ever been obtained that show whether any of the methods can be profitably employed, or which is the most valuable.

Variety Testing.

The value of the comparative tests of varieties of fruits, vegetables, flowers, etc., is often discussed. That it is a legitimate and important part of the work of the stations is shown in the demand made for the publications recording the results of such tests. When we consider the large number

of new varieties of fruits, vegetables, etc., offered to the public every year at high prices, with the claim of merits for them far above those of the standard sorts, and which the average grower cannot afford to buy and test, it is certain that the stations can save the people much loss and expense.

In the work of variety testing at this station in past years, the reports show that the new varieties reported as being the most valuable have been those that later were considered most valuable and were most largely grown by the commercial grower, while the varieties reported as having little or no value have been everywhere soon discarded by the growers who tested them. This work would be of much greater value, without doubt, if one or more sub-stations in different parts of the State could be established, where the same varieties could be tested under different conditions of soil and exposure.

The large number of new varieties of all kinds of fruit, vegetables, etc., being introduced every year, and generally with extravagant claims of merit, renders this work of the Experiment Station imperative, and the people should refuse to purchase such varieties until they have the endorsement of the stations of several States. A single season's trial of a variety is of very little value. It requires several years, at least, to prove the value of vegetables or even the more early maturing small fruits, while tree fruits require a much longer period.

Other Experiments.

Among the other experiments now under way may be mentioned the destruction of greenhouse insects by the use of hydrocyanic acid; the testing of the value and keeping qualities of some fifty-five varieties of celery; sub-irrigation in growing lettuce under glass; the use of different kinds of mulch for strawberries; methods of overcoming the asparagus rust; testing varieties of dwarf Lima beans, etc.

Reports will soon be made of the results of the variety tests of fruits, vegetables, etc.; the use of "Laurel Green" as an insecticide and fungicide; of arsenate of lead as an insecticide; and of other work done during the year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.
Assistants, E. B. HOLLAND, F. W. MOSSMAN, B. K. JONES, H. H. ROPER.

PART I. — LABORATORY WORK.

Outline of Year's Work.

PART II. — FEEDING EXPERIMENTS AND DAIRY STUDIES.

PART I.

EXTENT OF CHEMICAL WORK.

The work of the chemical laboratory connected with this department has very materially increased during the past year. There have been tested 150 samples of water, 197 samples of milk, 2 samples of oleomargarine, 1 sample of butter, 123 samples of miscellaneous substances. In addition to the above, which were sent to the station for examination, there have been analyzed 260 samples of milk and 388 samples of feed stuffs, in connection with experiments in progress by this and other divisions of the station, making a total of 1,147 substances which have passed through the laboratory within twelve months. There have also been carried on, for the Association of Official Agricultural Chemists, chemical investigations, relative to the meth-

ods best adapted for the estimation of starch in agricultural products. This has involved a great amount of chemical work, the extent of which it is impossible to express in mere figures.

Character of Chemical Work.

Water. — The analyses of water have been made by the same methods as heretofore, and with the same end in view, namely, to aid farmers and others in guarding against the danger arising from the use of waters coming from polluted springs and wells. Illness frequently occurs in the family, the cause of which it is often difficult to explain, until an examination of the water reveals its pollution with sink, privy, stable or other drainage. The waters tested show much the same condition as in former years; in round numbers, 15 per cent. could be pronounced excellent, 40 per cent. fair, 25 per cent. suspicious and 20 per cent. dangerous for drinking. Fully 50 per cent., therefore, were considered of a suspicious character. Three samples were found to contain lead, and had been known to have produced lead poisoning. We can only repeat the advice given in former years, in cautioning all who are obliged to depend upon wells and springs for their water supply to take every precaution to prevent any drainage from entering, and to keep the grounds about the well or spring free from all objectionable matter. Lead pipes should never be used to draw water through, especially if the water is free from mineral matter (soft).

Milk. — The most of the milk received at the station has been sent by farmers who ship their milk to Boston contractors. They had probably been notified by the contractors that their milk was below the Massachusetts standard,* and they wished to ascertain its exact quality, and what, if anything, could be done for its improvement. The larger part of this milk was found to contain 12 to 12.5 per cent. of solids and from 3.25 to 3.50 per cent. of fat, and was in all probability the unadulterated product of the cow. The contractor, however, because of the large amount of milk

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* The Massachusetts standard calls for 13 per cent. solids and 3.70 per cent. fat, excepting during April, May, June, July and August, when but 12 per cent. solids and 3 per cent. fat are required.

offered, can afford to be particular, and desires only that up to, or above the legal standard. In such cases there is nothing for the farmer to do but to add some grade Jersey or Guernsey cows to his herd. It certainly would be a long step forward, if milk were sold not simply as milk, but with a guarantee of composition. Milk containing 11.5 per cent. solids and 3 per cent. of fat should surely bring less per quart than milk containing 12, 13 or 14 per cent. solids, and 3.25, 4 or 5 per cent. fat.

Cattle Feeds. — At its session of 1897, the State Legislature passed a law authorizing the inspection of feed stuffs. The work is being carried out by this department, and it is hoped that it will result in keeping out poor and adulterated material, and in keeping the regular articles of as constant a composition as possible. Considerable adulterated cotton-seed meal was found on the market during the early spring months. This material consisted of a mixture of hulls and meal, the former ground very fine in order to conceal its identity. The adulterated product contained from 22 to 30 per cent. of protein, while a prime meal should show from 40 to 45 per cent. Farmers were warned through the agricultural and daily papers of the presence of the adulterated article, and cautioned against its purchase. The result of this has been to produce a feeling of uncertainty and to restrict the use of the genuine article. To overcome this, the American Cotton Oil Company have placed a guarantee of composition upon every bag put out by them. It is hoped other manufacturers will follow this example. *Farmers should by all means give the preference to the guaranteed article.*

Other new feed stuffs are those put out by the H. O. Company, under the name of dairy, horse and poultry feeds. The feeding values of these feeds are being investigated. Varieties of oat feeds, being mixtures of oat hulls with more or less corn meal, are found in the market without name or guarantee. Farmers are cautioned against their purchase, for the reason that the price asked is, as a rule, considerably in excess of their feeding value.

Methods for the Determination of Starch. — The work undertaken for the Association of Official Chemists, already

alluded to, has been reported to them. While more work will be done along this line, it has been quite clearly demonstrated that the so-called Maercker and Reinke methods for the estimation of starch in agricultural products are faulty, and will give altogether too high results. The only method from which reasonably accurate results may be expected is the diastase or malt method,* and this method has been adopted by the official chemists in place of all others.

Part II.

Experiments with Pigs.

Two experiments have been completed with pigs, and a third is now near completion. These experiments were designed to study the value of corn meal as compared with hominy and cerealine feeds for pork production, when fed in combination with skim-milk. Both these feeds are quite similar in composition. They consist of the hull, germ and more or less bran and starch removed from white corn, during the preparation of cracked hominy and cerealine flakes for human consumption. Cerealine is much more bulky than the hominy feed. These experiments will be published in detail later. It can be said, however, that pigs have made nearly, and in some cases fully, as good growth on these feeds as on an equal amount of corn meal.

Salt Marsh Hay.

A thorough investigation has been completed concerning the general character and feeding value of salt marsh hay. The results are being published in bulletin form. The practical conclusions, briefly stated, are as follows: —

The several varieties of salt hay have, ton for ton, from 10 to 17 per cent. less feeding value than average English hay. When 10 to 12 pounds of salt hay were fed daily, together with 7 or 8 pounds of grain and a bushel of ensilage, the ration produced within 2 to 5 per cent. as much milk and

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* Sachsse's method can be used for estimating starch in commercial starch and in potatoes.

butter as an equal amount of English hay similarly combined.

Because of the less market value of salt as compared with English hay, rations containing the salt hay, as given above, produced milk and butter from 10 to 20 per cent. less than did rations containing English hay. No objectionable flavor was noticed when the salt hay was fed directly after milking.

It is undoubtedly wise for farmers living near the salt marshes to feed salt hay and sell English hay. For the results in detail, and a fuller discussion, see the bulletin.

Digestion Experiments.

During the past year we have studied the amount of actual nutriment in salt hays, to which reference has already been made, in a number of new by-products and in green crops for soiling. Many of our results, together with practical conclusions therefrom, will soon be ready for publication.

COTTON-SEED FEED AS A HAY SUBSTITUTE FOR MILCH COWS.

J. B. LINDSEY, E. B. HOLLAND AND B. K. JONES.

THE EXPERIMENT CONCISELY DESCRIBED.

What Cotton-seed Feed is. — The seeds of the cotton plant are irregular, egg-shaped in form, and almost hidden by a tuft of white fibre which covers their surface. The meat of the seed is covered with a thick, tough hull of a black color. Machines have been invented to remove this hull, and the meat is subjected to warm pressure for the purpose of removing as much as possible of the oil. The pressed meat or cake is ground, and results in the decorticated, bright yellow cotton-seed meal of commerce. The black hull, covered with the white fibre, was formerly almost entirely used as fuel, and the ashes were sold for fertilizing purposes. Of late many southern farmers, at the recommendation of experiment stations in the south, have been mixing these hulls with the cotton-seed meal and feeding them to beef and dairy cattle, with very good success. Within the last few years this material, under the name of *cotton-seed feed*, has been offered in our Massachusetts markets. The manufacturers claim that the feed consists of 1,600 pounds of hull and 400 pounds of meal, thoroughly mixed by machinery. The price charged has been $13 per ton in car lots, delivered in Massachusetts, which would be equivalent to at least $15 in single tons. The feed, shipped in bags, is quite bulky, and, because of the white fibre covering the hull, looks somewhat like wool waste. Its color is light yellow, due to the admixture of the cotton-seed meal.

THE EXPERIMENTS BRIEFLY STATED.

The experiment station has conducted four experiments with this feed, two with milch cows and two with sheep.

The feed for the first experiment was furnished by the manufacturers. In the second experiment we procured the separate ingredients, and mixed the feed ourselves. Each of the two milk experiments was made with six cows. In the first experiment the feed consisted of a constant grain and ensilage ration, together with a good quality of first-cut hay and cotton-seed feed; in the second experiment there was a constant grain and mangel ration, in addition to the hay and cotton-seed feed. The cotton-seed feed was looked upon as being similar in character to hay, and, in attempting to get at its value, from 12 to 15 pounds were substituted daily for a like quantity of hay. The first experiment lasted twenty-one days and the second twenty-eight days. In case of digestion experiments, in which six single tests were made, some of the sheep received nothing but the cotton-seed feed, and others received half hay and half of the feed. While the cotton-seed feed has not an attractive appearance, the animals in all cases ate their daily rations with no apparent objections.

The Results.

I. The total average gain of the six cows in live weight during the cotton-seed period was 95 pounds, and during the hay period 166 pounds.

II. The production of milk, milk solids and butter fat was so nearly alike in the average of both experiments as to be within the limits of experimental error.

III. The cost of producing milk and butter with the hay and with the cotton-seed ration varied but very little.

IV. A ton of cotton-seed feed contained about 964 pounds of digestible matter, and a ton of the hay about 1,007 pounds of digestible material.

V. A full description of the experiments, together with all data bearing on the results, will be found further on.

Is Cotton-seed Feed economical for Massachusetts Farmers?

There would unquestionably be no advantage for the average farmer to feed this material in place of hay, unless he could sell his hay for a sufficient advance over the cost of

the feed to warrant the change. Milkmen in the vicinity of large cities, and others who are obliged to purchase their coarse feed, might find it to their advantage to use some of this material, especially if it could be bought for less than a good quality of hay. It is possible that animals would tire of this feed sooner than of hay. The cows used by the station consumed it continuously for over a month with no seeming objections. The cotton-seed feed must be looked upon from a feeding stand-point in the light of a hay substitute, and not as a grain feed, and only 8 to 10 pounds should be fed each animal daily, in place of a like amount of hay or other coarse fodder. Southern rather than northern farmers can utilize cotton-seed feed to the best advantage.

The Experiments in Detail.

In 1889 Stone * records the fact that increasing quantities of cotton-seed hulls and various mixtures of hulls and cotton-seed meal were being fed by the farmers of the south for beef and milk production. Since 1889 a great variety of digestion and beef-producing experiments have been made by the North Carolina station,† which have been productive of a large amount of information relative to the physiological and economic value of cotton-seed feed. The Texas experiment station ‡ has made experiments with milch cows to study the economic value of this feed in a variety of fodder rations.

In 1894 Armsby § published the results of two experiments with cotton-seed feed. In the first experiment the cows, five in number, were fed as follows: Ration I. consisted daily of 7.95 pounds of wheat bran and 11.69 pounds of cotton-seed feed; while Ration II. contained 3 pounds of cotton-seed meal, 7 pounds of corn meal, 6 pounds of corn fodder and 3.27 pounds of hay. Practically, the corn meal and cotton-seed meal of the second ration were matched against the bran, and cotton-seed meal contained in the cotton-seed feed of the first ration, leaving the corn fodder

* Tennessee Experiment Station, Vol. II., No. 3, 1889.

† Bulletins 80*c*, 81, 87*d*, 93, 97, 106, 109, 118.

‡ Bulletin 33, 1894.

§ Report Pennsylvania Experiment Station, page 44, 1894.

and hay to be compared with about the same quantity of cotton hulls. The results, as would naturally be expected, were in favor of Ration II. This latter ration contained also 4 pounds more of digestible matter. In the second trial, six cows were each given daily 6 pounds of Buffalo gluten feed and 2 pounds of wheat bran. Ration I. contained in addition 10.6 pounds of cotton-seed feed, and Ration II. 4 pounds of corn meal and 9.7 pounds of clover hay. It is not possible to regard this as a fair comparison, for any one can see at a glance that 4 pounds of corn meal and 9.7 pounds of clover hay (13.7 pounds) must give better results than 10.6 pounds of cotton-seed feed. At least a fairer comparison would have been to have matched the cotton-seed feed against a like quantity of clover hay. Simply because cotton-seed feed consists of a mixture of cotton-seed hulls with cotton-seed meal, it is not at all necessary when making a comparison to put the like amount of cotton-seed meal or other grain into the opposite ration. By so doing, one simply compares cotton-seed hulls with some other fodder or fodder combination. The hulls themselves have an inferior nutritive value; experiments have demonstrated that their nutritive effect is increased by the addition of the cotton-seed meal. In order, therefore, to get at the feeding value of this material, it must be regarded as a single feed stuff, and ought to be compared with other coarse fodders of similar composition. It has been the aim of the experimenter, in the two experiments that follow, to make such a comparison.

A. Composition of Cotton-seed Feed.

The first lot of feed, supplied through the kindness of Mr. H. C. Haskell of the Southern Cotton Oil Company of Savannah, Ga., was said to have been mixed in the proportion of 1,600 pounds of hulls to 400 pounds of meal. The lot for the second experiment we prepared ourselves, in the same proportion. The two lots varied very little in moisture, but, for the sake of more exact comparison, the results are presented in dry matter.

	No. 1 (Per Cent.).	No. 2 (Per Cent.).	Theoretical Protein Content of No. 2 (Per Cent.).	Composition of Two Samples of Hay fed in the Two Experiments (Per Cent.).	
				I.	II.
Ash, . . .	3.82	3.51	–	5.94	5.78
Protein, . .	13.02	11.98	13.85	11.07	8.41
Fibre, . . .	39.67	40.69	–	32.00	33.98
Extract matter, .	39.59	40.13	–	47.92	49.15
Fat, . . .	3.90	3.69	–	3.07	2.68

Both Nos. 1 and 2 run rather below the theoretical percentage of protein. This is not surprising, from the fact that it is extremely difficult to get a strictly average sample of this feed. It is impossible to grind the hulls fine, and in spite of all one can do, more or less of the meal will fall through the hulls and not be included in the sample. It will be noted that the cotton-seed feed and the hay resemble each other in chemical composition, excepting that the cotton-seed feed contains somewhat more fibre and less extract matter.

B. Digestibility of Cotton-seed Feed.

Recognizing the valuable information secured by digestion tests, six single trials with sheep were made of the two samples of feed. The sheep were grade Southdown mature wethers. In four cases the cotton-seed feed was fed alone, and in the remaining two the daily ration consisted of one-half hay and one-half cotton-seed feed. In both cases the results agree quite closely, except in case of the fat, which showed a digestibility of 98 per cent. when the cotton-seed feed was fed in connection with hay. This high result it was thought best to exclude from the average. The cotton-seed feed appeared to agree better with the sheep when fed in connection with hay than when fed by itself. In the latter case, at the close of the period the sheep began to show signs of diges-

tion disturbances, which would certainly have become quite pronounced had the feeding been continued much longer. The digestibility of the two different samples of cotton-seed feed was practically the same. The North Carolina station has made a very extended study of the digestibility of hulls and meal fed in different proportions. The Pennsylvania station has also made three single determinations. These results, in addition to our own, are tabulated below : —

Digestion Coefficients.

	Proportions fed.	Number Single Determinations.	Dry Matter (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Extract Matter (Per Cent.).	Fat (Per Cent.).
Massachusetts station,	4-1	6	56	41	56	59	92
North Carolina station,	6-1	2	46	46	40	50	82
North Carolina station,	4-1	2	54	54	45	58	85
North Carolina station,	3-1 1½-1	9	54	64	47	54	85
Pennsylvania station,	5-1	3	43	36	31	54	84
Hay of mixed grasses with ten per cent. protein for comparison.	-	-	58	58	60	59	48

The experiments made by the North Carolina station (4–1) and by the Pennsylvania station were carried out with steers. The only difference between the results obtained by the Massachusetts station and those recorded by the North Carolina station (4–1) consists in the higher percentage of protein and the lower percentage of fibre digested by the steers in the North Carolina experiments. The coefficients for fat digestibility also show some variation, but, the fat percentage being comparatively small, the difference is not of so much account. The coefficients obtained by Armsby are lower than would be expected. The coefficients of digestibility for an extra quality of hay are not very noticeably higher — excepting the protein — than those for the cotton-seed feed.

According to the average coefficients of digestibility, a ton of the hay and a ton of the cotton-seed feed fed in the

milk experiments would contain the following amounts of digestible organic nutrients : —

One ton hay, ...	1,007.3
One ton cotton-seed feed, ...	964.4

One would therefore suppose that a ton of cotton-seed feed would have nearly the same feeding value as a like quantity of hay. There might be one exception to the above statement, in that it is possible that rather more energy would be required to digest the cotton-seed feed than the hay.

C. Milk Experiments with Cotton-seed Feed.

Experiment I.

This experiment was conducted during April and May, 1896. The animals, six in number, were evenly divided into two lots. In order to counteract the natural milk shrinkage, three of the animals in the first half of the experiment were fed the cotton-seed feed ration, while the other three were having the hay ration. In the second half this order was reversed. Each half of the experiment lasted twenty-one days, and from seven to ten days were allowed between the halves.

History of the Cows.

NAME.	Breed.	Age (Years).	Last Calf dropped.	Number of Days with Calf.	Milk Yield at Beginning of Experiment (Pounds).
Ada, . .	Grade Ayrshire,	7	Oct. 1	106	19
Red Spot, .	Grade Durham, .	6	Sept. –	90	21
Bessie, .	Grade Ayrshire,	7	Sept. 10	69	25
Beauty, .	Grade Jersey, .	5	Sept. 15	96	20
Red, . .	Grade Durham, .	7	Oct. 8	141	20
Spot, . .	Grade Durham, .	7	Oct. 8	141	20

Five of the above cows had been in two previous experiments since October, 1895.

Dates of the Experiment.

	Cotton-seed Ration.	Hay Ration.
April 8 through April 28, . . .	Cows 3, 4, 5	Cows 1, 2, 6
May 11 through May 31, . . .	Cows 1, 2, 6	Cows 3, 4, 5

Rations consumed Daily (Pounds).

PERIOD.	Name.	Hay.	Cotton-seed Feed.	Wheat Bran.	Peoria Gluten Feed.	Linseed Meal.	Millet and Soy Bean Ensilage.
Cotton-seed feed.	Ada, . .	–	10	2	3	1	15,
	Red Spot, .	–	13	3	2	2	20
	Bessie, . .	–	15	3	2	2	20
	Beauty, . .	–	15	3	2	2	20
	Red,. . .	–	15	3	2	2	20
	Spot, . .	–	13	3	2	2	20
Hay.	Ada, . .	10	–	2	3	1	15
	Red Spot, .	13	–	3	2	2	20
	Bessie, . .	15	–	3	2	2	20
	Beauty, . .	15	–	3	2	2	20
	Red,. . .	14.2	–	3	2	2	20
	Spot, . .	13	–	3	2	2	20
Average cotton-seed feed.		–	13.5	2.83	2.17	1.83	19.17
Average hay, . .		13.47	–	2.83	2.17	1.83	19.17

Although but three of the six cows received the same ration at the same time, each animal received during the experiment the two different rations for exactly the same length of time. It will be observed that the only difference between the rations consists in the substitution of the cotton-

seed feed for the hay, and *vice versa*. The entire rations were eaten clean, excepting a small amount of hay refused by Red, which was preserved, analyzed and deducted from the total fed. The feeds were weighed out daily and given in two portions. Water was before the animals constantly. The cows were carded daily, and allowed the run of a yard in pleasant weather.

Digestible Nutrients in Daily Rations (Pounds).

Period.	Name.	Total Dry Matter.	Digestible.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Cotton-seed feed	Ada,	17.36	1.77	8.30	.67	10.74	1:5.63
	Red Spot,	21.88	2.23	10.10	.82	13.15	1:5.45
	Bessie,	23.42	2.31	10.82	.86	13.99	1:5.61
	Beauty,	23.42	2.31	10.82	.86	13.99	1:5.61
	Red,	23.42	2.31	10.82	.86	13.99	1:5.61
	Spot,	21.88	2.23	10.10	.82	13.15	1:5.45
Hay	Ada,	17.30	1.92	8.74	.50	11.16	1:5.20
	Red Spot,	21.81	2.42	10.70	.59	13.71	1:5.03
	Bessie,	23.90	2.57	11.05	.64	14.26	1:4.92
	Beauty,	23.90	2.57	11.05	.64	14.26	1:4.92
	Red,	23.19	2.53	10.72	.63	13.88	1:4.86
	Spot,	21.81	2.42	10.70	.59	13.71	1:5.03
Average cotton-seed feed.		21.89	2.19	10.16	.82	13.17	1:5.56
Average hay,		21.99	2.41	10.49	.60	13.50	1:4.99

The coefficients of digestibility for the cotton-seed feed and for the hay used in calculating the above digestible nutrients were those obtained in our experiments with sheep. Average coefficients were used for the grain feeds. The above results show but little variation in the digestible amounts of the several groups contained in the two rations.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Ada.	Red Spot.	Bessie.	Beauty.	Red.	Spot.	Total Herd Gain.
Cotton-seed period,	Beginning,	771	891	795	937	1010	967	10
	End,	771	888	792	928	1025	977	
Hay period,	Beginning,	775	892	861	1000	1070	965	40
	End,	775	902	855	1012	1082	977	

Two weights were taken of each animal at the beginning and two at the end of the experiment. No marked variations were noted due to the influence of either ration.

Yield of Milk and Butter.

PERIOD.	Cows.	Total Yield of Milk (Pounds).	Daily Yield of Milk (Pounds).	Daily Yield of Milk (Quarts).	Total Milk Solids (Pounds).	Total Butter Fat (Pounds).	Total Butter (Pounds).	Daily Yield of Butter (Pounds).
Cotton-seed Feed.	Ada,	395.48	18.83	8.76	54.60	19.53	22.78	1.08
	Red Spot,	439.12	20.91	9.72	62.58	22.89	26.70	1.27
	Bessie,	542.11	25.71	11.96	73.50	26.67	31.11	1.48
	Beauty,	444.00	21.14	9.83	66.99	24.99	29.15	1.39
	Red,	416.62	19.82	9.22	58.38	21.00	24.50	1.17
	Spot,	337.25	16.06	7.47	50.82	18.27	21.31	1.01
Hay.	Ada,	402.71	19.18	8.92	54.60	18.60	21.70	1.03
	Red Spot,	458.75	21.84	10.16	64.05	21.29	24.84	1.11
	Bessie,	526.86	25.09	11.67	70.35	23.81	27.78	1.32
	Beauty,	399.89	19.04	8.86	58.17	20.35	23.74	1.13
	Red,	275.50	13.12	6.43	38.22	12.84	14.98	.71
	Spot,	419.50	19.98	9.29	61.53	22.11	25.80	1.23
Total cotton-seed feed,		2,574.58	122.47	56.96	366.87	133.33	155.55	7.40
Total hay,		2,483.21	118.25	55.33	346.92	119.00	138.84	6.60
Percentage increase cotton-seed feed over hay.		3.6+	-	-	5.44+	10.76+	-	-

The cotton-seed feed ration gave a slightly larger amount of milk than the hay ration. A 5.4 percentage increase in the amount of total solids is also noted, while fully ten per

cent. more butter fat was produced by the cotton-seed ration. This latter result could hardly have been expected. Should cotton-seed feed exert a favorable influence in increasing the relative amount of butter fat in the milk, other experiments would show similar results, which we shall presently show has not been the case. A part of the decrease in the amount of milk, solids and fat produced by the hay ration can be accounted for in the sudden shrinkage of Cow V. (Red) in the second (hay) period. This cow was a grade Durham, and at the beginning of her second period was about 105 days from calving time. She began then to dry off rapidly, showing a shrinkage of 34 per cent. in yield of milk from that produced in the previous period, while other animals shrank only from 5, to in one case 20 per cent. Had Red shrank only 20 per cent., the total decrease in milk yield in the hay period would have been but a trifle over 1 per cent. The results of this experiment make rather more of a favorable showing for the cotton-seed feed than one would naturally expect, judging from its composition and digestibility. Before, therefore, drawing positive conclusions, the reader is referred to the results of a second experiment, described further on.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

Dry Matter required to Produce —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	107.10	111.56	100 pounds milk, .	64.40	68.49
1 pound milk solids, .	7.52	7.98	1 pound milk solids, .	4.52	4.90
1 pound milk fat, . .	20.69	23.27	1 pound milk fat, .	12.44	14.28
1 pound butter, . .	17.75	19.99	1 pound butter, . .	10.68	12.27

Market Cost of Feed Stuffs.

Wheat bran, ...	$15 00	per ton.
Peoria gluten feed, ...	15 00	"
Linseed meal, ...	20 00	"
Millet and soya bean ensilage, . .	3 50	"
Hay, ...	15 00	"
Cotton-seed feed, ...	15 00	"

With the above figures as a basis, we obtain the following figures for the cost of feed required to produce milk and butter: —

	COWS.	Daily Feed (Cents).	100 Pounds Milk (Cents).	Quart of Milk (Cents).	Pound Butter Fat (Cents).	Pound Butter (Cents).
Cotton-seed period.	Ada,	14.87	79.00	1.69	15.99	13.77
	Red Spot,	19.00	90.90	1.95	17.43	15.00
	Bessie,	20.50	79.70	1.71	16.14	13.85
	Beauty,	20.50	97.00	2.08	17.23	14.03
	Red,	20.50	103.40	2.22	20.50	17.52
	Spot,	19.00	118.20	2.54	21.84	18.81
Hay period.	Ada,	14.87	77.50	1.67	16.71	14.43
	Red Spot,	19.00	87.00	1.87	18.81	16.10
	Bessie,	20.50	81.70	1.76	18.14	15.53
	Beauty,	20.50	107.60	2.31	21.13	18.14
	Red,	19.90	151.70	3.09	32.62	28.03
	Spot,	19.00	95.00	2.05	18.09	15.45
Average cotton-seed feed period.		19.06	94.70	2.03	18.19	15.49
Average hay period,		18.96	100.10	2.12	20.92	17.94

The two rations costing the same, the cost of producing milk and butter was rather favorable to the cotton-seed feed ration.

Experiment II. (1896).

In view of the results obtained in the first experiment, it was thought advisable to conduct a second under practically the same conditions. The six cows were all approximately fresh in milk. The experiment was carried out in exactly the same way as the preceding one.

History of Cows.

NAME.	Breed.	Age (Years).	Last Calf Dropped.
Mary, . . .	Grade Jersey, . .	9	July 1.
Jennie, . . .	Grade Guernsey, .	6	September.
Nora, . . .	Grade Jersey, . .	10	August 23.
Beauty, . . .	Grade Jersey, . .	6	September 15.
Red, ...	Grade Durham, . .	8	August 20.
Spot, ...	Grade Durham, . .	8	August 17.

The cows were farrow at the beginning of the experiment, and all were served during the progress of the trial.

Dates of the Experiment.

	Cotton-seed Period.	Hay Period.
October 6 through November 3, . .	Cows 1, 2, 5.	Cows 3, 4, 6.
November 17 through December 15, .	Cows 3, 4, 6.	Cows 1, 2, 5.

Rations eaten Per Day (Pounds).

	NAME.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Cotton-seed period.	Mary, . . .	2	15	15	5	3
	Jennie, . . .	3	12	15	5	3
	Nora, . . .	–	15	15	5	3
	Beauty, . . .	5	15	15	5	3
	Red, . . .	3	15	15	5	3
	Spot, . . .	3	14.46	15	5	3

Rations eaten Per Day (Pounds) — Concluded.

	Name.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Hay period.	Mary,	17	–	15	5	3
	Jennie,	15	–	15	5	3
	Nora,	15	–	15	5	3
	Beauty,	20	–	15	5	3
	Red,	18	–	15	5	3
	Spot,	18	–	15	5	3
Average cotton-seed feed period.		2.68	14.41	15	5	3
Average hay period,		17.17	–	15	5	3

It was not considered advisable to feed more than from 12 to 15 pounds of the cotton-seed feed daily, and the additional quantity of coarse fodder was secured by adding from 2 to 5 pounds of hay, to suit the appetites of the various animals. We have, then, 12 to 15 pounds of cotton-seed feed, compared with a like amount of hay. The cotton-seed feed was mixed daily in the proportion of 4 pounds of hulls to 1 pound of meal. The hay was a mixture of grasses, with Timothy predominating. Some clover was scattered through the mixture.

Digestible Matter in Rations (Per Cent.).

	Name.	Total Dry Matter.	Digestible.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Cotton-seed period	Mary,	23.20	2.45	10.58	.83	13.86	1:5.08
	Jennie,	21.44	2.37	9.78	.76	12.91	1:4.85
	Nora,	21.44	2.37	9.76	.81	12.94	1:4.85
	Beauty,	25.83	2.57	11.82	.87	15.26	1:5.36
	Red,	24.07	2.49	10.99	.85	14.33	1:5.60
	Spot,	23.61	2.47	10.77	.83	14.07	1:5.08

Digestible Matter in Rations (Per Cent.) — Concluded.

	NAME.	Total Dry Matter.	DIGESTIBLE. Protein.	DIGESTIBLE. Carbohydrates.	DIGESTIBLE. Fat.	DIGESTIBLE. Total.	Nutritive Ratio.
Hay period.	Mary,	23.17	2.41	10.67	.56	13.64	1:4.95
	Jennie,	21.42	2.33	9.85	.54	12.72	1:4.77
	Nora,	21.42	2.33	9.85	.54	12.72	1:4.77
	Beauty,	25.78	2.53	11.91	.60	15.04	1:4.30
	Red,	24.08	2.45	11.08	.58	14.11	1:5.00
	Spot,	24.08	2.45	11.08	.58	14.11	1:5.00
Average cotton-seed feed period.		23.26	2.45	10.62	.82	13.64	1:5.14
Average hay period,		23.32	2.42	10.74	.57	13.72	1:5.00

The amounts and proportions of digestible matter in each of the two rations are identical. In calculating the above rations, average digestion coefficients were taken for the grains, the coefficients obtained at this station for the cotton-seed feed, and in case of the hay, the coefficients obtained by us for hay of similar appearance and composition. It must be remembered that the above digestible material in the two rations is only estimated. It is therefore quite possible that, had actual digestion experiments been made with the cows, these figures may have been somewhat modified.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Mary.	Jennie.	Nora.	Beauty.	Red.	Spot.	Total Gain.
Cotton-seed period,	Beginning,	768	818	745	943	1,006	1,007	–
	End,	767	840	767	954	1,042	1,002	85
Hay period,	Beginning,	829	897	757	946	1,096	954	–
	End,	825	888	780	973	1,116	1,024	126

The cows were weighed at the same time for three consecutive days at the beginning and end of the experiment.

Four of the six cows were rather thin in flesh at the beginning of the test, and made gains on both rations. The hay period showed a herd increase of 41 pounds over the cotton-seed period.

Milk and Butter Yields (Pounds).

PERIOD.	Cows.	Total Milk.	Daily Milk.	Daily Quarts.	Total Milk Solids.	Total Fat.	Total Butter.	Daily Butter.
Cotton-seed period.	Mary,	596.88	21.32	9.92	83.38	28.29	33.00	1.18
	Jennie,	609.97	21.78	10.13	88.81	30.50	35.59	1.27
	Nora,	519.12	18.54	8.62	69.81	23.62	27.56	.98
	Beauty,	587.68	20.99	9.76	84.75	30.97	36.13	1.29
	Red,	549.94	19.64	9.13	67.63	21.28	24.82	.88
	Spot,	428.77	15.31	7.12	62.23	22.42	26.16	.93
Hay period.	Mary,	575.64	20.55	9.57	79.83	27.34	31.90	1.14
	Jennie,	527.12	18.82	8.75	80.49	30.46	35.54	1.27
	Nora,	613.34	21.89	10.17	80.77	24.78	28.91	1.03
	Beauty,	685.67	24.47	11.38	97.85	33.60	39.20	1.40
	Red,	557.00	19.89	9.25	69.62	22.72	26.51	.95
	Spot,	491.17	17.56	8.17	70.83	23.23	27.10	.97
Average cotton-seed feed ration.		548.73	19.59	9.10	76.10	26.18	30.54	1.09
Average hay ration,		574.99	20.53	9.55	79.90	27.02	31.53	1.13
Percentage increase hay over cotton-seed period.		4.6+	-	-	4.8+	3.1+	-	-

In this experiment, the results are the reverse of those obtained in the first test, the hay period yielding several per cent. more milk, milk solids and fat. Our observations of the animals from day to day during the trial indicated that the cotton-seed feed ration was falling slightly behind the hay ration. The animals, being in the early part of the lactation period, would naturally be more sensitive to the effect of food than in the latter portion of the period of lactation.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

DRY MATTER REQUIRED TO PRODUCE —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	118.70	113.60	100 pounds milk, .	70.90	66.90
1 pound milk solids, .	8.56	8.18	1 pound milk solids, .	5.11	4.81
1 pound milk fat, . .	24.88	24.17	1 pound milk fat, .	14.86	14.22
1 pound butter, . .	21.38	20.70	1 pound butter, . .	12.77	12.18

Market Cost of Feed Stuffs.

Wheat bran, ...	$14 00	per ton.
Chicago gluten meal, ...	18 00	"
Mangolds, ...	3 00	"
Hay, ...	15 00	"
Cotton-seed feed, ...	15 00	"

Cost of Feed to produce Milk and Butter. Average for Six Cows (Cents).

	Daily Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton-seed period, ...	21.32	110.6	2.38	23.40	20.10
Hay period, ...	21.32	104.9	2.26	22.69	19.33
Increased percentage cost of cotton-seed over hay period.	-	5.2+	-	-	3.2+

The cotton-seed rations slightly increased the cost of the milk and butter.

D. AVERAGE RESULTS FROM TWO EXPERIMENTS.

It is thought desirable to bring together the results of both experiments, believing that they will give a fair representation of the relative values of like quantities of cotton-seed feed and a good quality of hay.

1. Total Live Weight gained by the Six Cows in Both Experiments (Pounds).

Cotton-seed feed periods, ...	95
Hay periods, ...	166

2. Average Dry and Digestible Matter Consumed Daily (Pounds).

	Total Dry Matter.	Digestible.				Nutritive Ratio.
		Protein.	Fat.	Carbohydrates.	Total.	
Cotton-seed period,	22.57	2.32	.82	10.39	13.40	1 : 5.35
Hay period,	22.65	2.41	.59	10.61	13.61	1 : 5.00

These figures show very slight variations.

3. Total Milk and Butter Yields (Pounds).

	Milk.	Milk Solids.	Milk Fat.	Butter.
Cotton-seed period,	5867	823.5	290.4	338.8
Hay period,	5933	826.3	281.1	328.0
Percentage increase hay over cotton-seed,	1.1+	.34+	3.2—	3.2—

These variations can be regarded as within the limits of experimental error.

4. Average Feed Cost of Milk and Butter (Cents).

	Daily Cost of Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton seed period,	20.19	102.6	2.20	20.79	17.79
Hay period,	20.14	102.5	2.19	21.80	18.63
Percentage increased cost of hay over cotton-seed.	±	±	±	4.63+	4.5+

The 4.6 percentage increased cost of butter in the hay period is due to the rather unexpected results in the first experiment.

5. Dry and Digestible Matter required to produce Milk and Butter.

I. Dry Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period,	112.9	8.04	22.79	19.56
Hay period,	112.6	8.08	23.72	20.37

II. Digestible Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period,	67.65	4.81	13.65	11.72
Hay period,	67.69	4.85	14.25	12.22

General Conclusions.

Cotton-seed feed, from its appearance, is certainly not an attractive looking article for consumption. The cotton-seed hulls, comprising the bulk of the feed, consists of the dark seed coats, together with an entangling mass of fibre. They are difficult to masticate, and quite indigestible. The cotton-seed meal with which the hulls are mixed imparts its flavor to the material, and actually increases the digestibility of the hulls. In our experiments we have had no trouble in inducing animals to eat 12 to 15 pounds daily within three or four days. The two experiments have shown cotton-seed feed to give as large milk and butter yields, at as low a cost, as a good quality of hay. The writer is of the opinion, however, that this feed requires more energy for its digestion than hay, and, when fed for any length of time, would have a tendency to induce digestive disturbances. A mixture of hulls and meal could probably be turned to better account for fattening steers than as a continuous feed for dairy cows. Massachusetts farmers could derive no benefit from feeding this material in place of hay. For those who are obliged to purchase all of their coarse feeds, it might be desirable to use one-half of this material in place of hay, provided it could be purchased for somewhat less money. Cotton-seed feed should be consumed where it is produced. For the farmers of the south it is undoubtedly a cheap source of coarse feed, and, when fed in moderate quantities, will unquestionably return good results.

Analytical Data.

Dry Matter Determinations (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton seed-Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
April 8 through April 28, .	90.33	18.79	89.00	87.89	90.58	93.04
May 11 through May 31, .	89.84	20.58	88.10	87.86	90.48	93.23

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Hay * and cotton-seed periods, . .	87.60	8.09	87.8	87.2	90.6

* The dry matter determinations varied so little in the two halves of this experiment that the average in each case was taken.

Composttion of Feeds (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
Ash, ...	5.94	12.77	3.82	6.42	4.94	1.07
Fibre, ...	32.00	34.02	39.67	11.37	7.26	7.13
Fat, ...	3.07	2.59	3.90	5.73	7.05	7.59
Protein, ...	11.07	9.40	13.02	18.68	41.99	23.83
Extract matter, . . .	47.92	41.22	39.59	57.80	38.76	60.38

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Ash, ...	5.78	15.49	3.51	7.11	1.52
Fibre, ...	33.98	10.67	40.69	12.08	3.21
Fat, ...	2.68	.73	3.69	5.69	7.38
Protein, ...	8.41	14.35	11.98	18.12	40.38
Extract matter, ...	49.15	58.76	40.13	57.00	47.51

Coefficients of Digestibility.

Experiment I.

	Hay.	Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.	Chicago Gluten Meal.	Mangolds.
Fibre,	66	69	59	22	57	78	-	-
Fat,	53	72	89	71	89	79	-	-
Protein,	62	57	39	78	89	83	-	-
Extract Matter,	64	59	58	68	78	90	-	-

Experiment II.

	Hay.	Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.	Chicago Gluten Meal.	Mangolds.
Fibre,	58	-	55	22	-	-	-	43
Fat,	50	-	93	68	-	-	93	-
Protein,	54	-	42	79	-	-	89	75
Extract Matter,	56	-	59	69	-	-	93	91

Composition of Milk (Per Cent.).

Experiment I.

	Ada.		Red Spot.		Bessie.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	13.84	4.93	14.01	4.84	13.63	4.93
	13.82	5.00	14.48	5.59	-	-
Average,	13.83	4.96	14.24	5.21	13.63	4.93
Hay period,	13.57	4.62	13.95	4.64	13.26	4.53
	-	-	-	-	13.47	4.52
Average,	13.57	4.62	13.95	4.64	13.36	4.52

Experiment I. — Concluded.

	Beauty.		Red.		Spot.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	15.08	5.62	14.03	5.05	14.88	5.33
	-	-	-	-	15.28	5.48
Average, . . .	15.08	5.62	14.03	5.05	15.08	5.40
Hay period, . . .	14.54	5.13	13.91	4.72	14.77	5.27
	14.61	5.05	13.87	4.60	-	-
Average, . . .	14.57	5.09	13.89	4.66	14.77	5.27

Experiment II.

	Mary.		Jennie.		Nora.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	13.96	4.64	14.36	4.73	13.39	4.48
	13.81	4.80	14.58	5.33	13.44	4.58
	14.20	4.93	14.58	4.92	13.52	4.63
	13.91	4.74	14.73	5.00	13.45	4.50
Average, . . .	13.97	4.74	14.56	5.00	13.45	4.55
Hay period, . . .	13.76	4.73	14.79	5.45	13.00	3.81
	13.86	4.75	15.39	5.88	12.93	4.10
	14.01	4.85	15.55	6.00	13.46	4.17
	13.85	4.68	15.37	5.78	13.28	4.07
Average, . . .	13.87	4.75	15.27	5.78	13.17	4.04

Experiment II. — Concluded.

	Beauty.		Red.		Spot.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	14.62	5.35	12.48	3.89	14.57	5.08
	13.95	4.85	11.88	3.93	14.77	5.05
	14.66	5.48	12.60	4.02	14.92	5.15
	14.46	5.40	12.23	3.63	13.90	5.63
Average,	14.42	5.27	12.30	3.87	14.54	5.23
Hay period,	-	-	12.26	4.00	14.01	4.34
	14.12	4.93	12.41	4.05	14.14	4.75
	14.49	4.97	12.74	4.20	14.59	4.94
	14.19	4.80	12.53	4.08	14.94	4.91
Average,	14.27	4.90	12.49	4.08	14.42	4.73

Average Results of Six Cows.

	Experiment I.		Experiment II.	
	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	14.31	5.18	13.87	4.78
Hay period,	14.02	4.80	13.91	4.71

Each distinct analysis represents a composite sample from 8 different milkings. In Experiment I., samples were taken for four days of the last two weeks only. In Experiment II., each analysis represents the comparison of the milk for each of the four weeks.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Two bulletins have been issued from this department during the year, — one on the habits, food and economic value of the American toad (*Bufo lentiginosus americanus*), and one on the brown-tail moth (*Euproctis chrysorrhœa*). I have been able in the intervals of other duties to prepare a monograph of the plume-moths (*Pterophoridæ*) of North America, which is published with illustrations in the thirty-fifth annual report of the college. A large amount of time has also been devoted to the work on the gypsy moth in the eastern part of the State.

San José Scale.

The San José scale (*Aspidiotus perniciosus*) has appeared in many places in Massachusetts, having been received on nursery stock from nurseries both in this and in other States. In the early part of the season my assistants visited, as far as possible, all the nurseries in the State, and carefully examined them for this scale. Most of them appeared to be entirely free from this insect, but a few were more or less infested. The owners of these infested nurseries have taken the most active measures to destroy this pest, under the supervision of one of my assistants. Many of the nurserymen do not raise a sufficient amount of stock to supply all of their orders, and often purchase from outside sources. This stock is often received and sent out without examination, and in this way it is possible for the San José scale to be distributed by those whose nurseries are not infested. A bulletin on the San José scale will be published as soon as other duties will permit, in which will be given a more complete account of the condition of the nurseries visited, together with the measures taken to eradicate the pest.

The scale insects have been and are still being introduced into this country from other parts of the world, and in this way we are liable at any time to find new or unknown species on our fruit or ornamental trees and shrubs and in our greenhouses. It therefore seems wise to learn as much as possible about these insects, in order that we may know what to do with those already here, and any that may hereafter be brought into this country. To this end, more than six hundred circular letters were sent out to all entomologists whose names and addresses could be obtained, asking for specimens of two genera of the scale insects, and already a large amount of material has been received. Prof. R. S. Lull has undertaken to work up and prepare a monograph of the genus *Pulvinaria*, and Mr. R. A. Cooley a monograph of the genus *Chionaspis*. Very commendable progress has already been made by these two gentlemen.

Army Worm.

During the summer of 1896 the army worm (*Leucania unipuncta*) was very abundant in Amherst and in many other parts of the State, often in destructive numbers, and in the correspondence with this department information concerning this insect was asked for more than of all others combined. During the summer of 1897, however, the army worm seems to have been present in so few numbers as to have done no harm, and it was not referred to in a single letter received by me. It is a well-known fact that this insect has never in the past appeared in destructive numbers two years in succession in the same place, and the past season seems to have been no exception. The caterpillars were reported in many cases to have been more or less infested with the eggs of a parasitic fly. These eggs no doubt hatched and the young maggots made their way into the caterpillars and destroyed them, thus reducing the army worm to insignificant numbers, so that the few remaining have been entirely overlooked.

Plant Lice.

While the army worm has been very scarce during the past season, the aphids or plant lice have been very abundant on trees and shrubs, and many letters have been received, asking

how to destroy them. The best method, so far as known, is to spray the trees with kerosene emulsion; but in spraying it is very difficult to reach every insect, and, as they multiply very rapidly, they soon become as abundant as ever, and it becomes necessary to spray the trees or shrubs repeatedly after short intervals.

Tobacco Cutworm.

Early in the season cutworms were said to be destroying the young tobacco plants in the tobacco fields of the Connecticut valley, and specimens that were brought in and bred to maturity developed into moths which proved to be *Carneades messoria*. The caterpillars of this species partake of a rather varied diet, consisting not only of tobacco, but also of cabbage, corn, potatoes, spinach, onions, lettuce and fruit trees. The usual method taken by our tobacco growers, so far as I can learn, is to reset tobacco plants where they have been cut off by the worms, and at the same time dig out and destroy the worm that has done the mischief.

Canker Worms.

Four years ago canker worms began to increase so rapidly in this town that public attention was called to them, and a general account of the species occurring in Massachusetts was given with illustrations in Bulletin No. 20, published in January, 1893. In that bulletin the usual remedies were given. These consisted of tacking bands of heavy paper around the trunks of the trees and painting these bands with prepared printers' ink, repainting with the ink as often as it became dry or hardened enough to permit the females to cross the band. The method of protecting the trees with oil troughs of zinc or tin around the trunks was also mentioned. It was finally stated that probably the most effectual method was to spray the trees with Paris green in water as soon as the eggs hatched in the spring. A further account of canker worms was given in Bulletin No. 28, published in April, 1895.

A careful study of the different methods used to destroy these insects, which are so prevalent in many parts of this Commonwealth, has been made on thirteen apple trees on my own premises in Amherst. Three years ago these trees were

carefully banded with heavy paper and painted with Morrill's tree ink early in the spring, when the first females began to ascend the trees, and the painting was repeated as often as necessary. It was found that the ink would often harden on the trees even during the night following the application, and remain hard on the shady side long enough in the morning for some of the females to ascend the tree on that side, so that this method did not prove to be a perfect protection. The cost of the materials and of their application averaged about fifty cents to each tree.

The oil troughs are also quite expensive, and often leak so that the rain displaces the oil and then evaporates, allowing the females to ascend the trees; or spiders spin their webs across beneath the overhanging protection, forming a bridge on which the moths may easily pass, so that this device does not form a perfect protection.

Two years ago these trees were sprayed with Paris green in water, in the proportion of one pound to one hundred and fifty gallons, at a cost of five cents a tree, allowing fifteen cents an hour for labor. There was a strong wind blowing, and more time was required to do the work than would otherwise have been the case. Last year the same trees were sprayed with Paris green, in the same proportion as before. At this time it was nearly calm, and the cost of spraying was three cents a tree. The contrast between these trees and those on adjacent lots were very marked, for the sprayed trees retained their foliage and yielded a full crop, while the unsprayed trees were stripped of leaves, and bore no fruit. These trees were sprayed but once, and this method appears to have been more effectual and far cheaper than the others. In case of rain it might be necessary to repeat the spraying, but even then it would be the cheaper method.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, GEORGE D. LEAVENS.

I. Report on Official Inspection of Commercial Fertilizers.
II. Report on General Work in the Chemical Laboratory.
III. Observations with Special Fertilizers on Tobacco raised in Massachusetts.

I. REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1897.

CHARLES A. GOESSMANN.

Sixty-six manufacturers and dealers in commercial fertilizers and agricultural chemicals have secured, during the past year, licenses for the sale of their goods in the State. Thirty-six of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, six in Connecticut, three in Rhode Island, three in Vermont, two in Pennsylvania, one in Maryland, one in Illinois, one in Ohio and three in Canada.

The number of distinct brands licensed, including agricultural chemicals, amounted to two hundred and ninety.

The collecting and sampling of the material for official analyses were in charge of Mr. R. H. Smith, a graduate of

the Massachusetts Agricultural College in the class of 1892, who since his graduation has been an efficient assistant in the chemical laboratory of the experiment station for the examination of commercial fertilizers.

Four hundred and fifteen samples of fertilizer have thus far been collected during the present year; of these, three hundred and one samples, representing two hundred and twenty-three distinct brands, were analyzed by the close of the month of November, and the results published in July and November bulletins, Nos. 48 and 49, of the Hatch Experiment Station of the Massachusetts Agricultural College. The remaining samples, in common with others coming under our observation before the expiration of the licenses, will be analyzed in due time, and the results published in conformity with our laws for the regulation of the trade in commercial fertilizers.

The results of the inspection during the past season are, on the whole, quite satisfactory, and if anything are an improvement on the results of the preceding year. The beneficial results of improved machinery and of improved skill in the management of the manufacture of fertilizers show themselves in a marked degree when compared with the general character of commercial fertilizers in earlier periods of the business.

To render the actual conditions of the trade in commercial fertilizers during the past season more prominent, a summary of our results is here inserted. In reading the subsequent statement, it has to be remembered that only the lowest stated guarantee is legally binding in all sales: —

(*a*) Where three essential elements of plant food were guaranteed: —

Number with three elements equal to or above the highest guarantee,	3
Number with two elements above the highest guarantee,	2
Number with one element above the highest guarantee,	60
Number with three elements between the lowest and highest guarantee,	69
Number with two elements between the lowest and highest guarantees,	63
Number with one element between the lowest and highest guarantees,	16

Number with two elements below the lowest guarantee,	6
Number with one element below the lowest guarantee,	29

(*b*) Where two essential elements of plant feed were guaranteed: —

Number with two elements above the highest guarantee,	3
Number with one element above the highest guarantee,	10
Number with two elements between the lowest and highest guarantees,	13
Number with one element between the lowest and highest guarantees,	12
Number with one element below the lowest guarantee,	6
Number with two elements below the lowest guarantee,	3

(*c*) Where one essential element of plant food was guaranteed: —

Number above the highest guarantee,	10
Number between the lowest and highest guarantees,	23
Number below the lowest guarantee,	1

The modes of analyses adopted in this work were in all essential points those recommended by the Association of Official Chemists.

Attention has been called, in previous reports, to the fact that the introduction of a more liberal amount of potash into the make-up of a large class of so-called complete manures has become from year to year more general. This change has been slow but decided, and in a large degree may be ascribed to the daily increasing evidence, resulting from actual observations in field and garden, that the farm lands of Massachusetts are frequently especially deficient in potash compounds, and consequently need in many instances a more liberal supply of available potash from outside sources to give satisfactory returns. Whenever garden vegetables, fruits and forage crops constitute the principal products of the land, this recent change in the mode of manuring deserves a particularly careful trial; for the crops raised consume exceptionally large quantities of potash, as compared with grain crops. In view of these facts, it will be conceded that a system of manuring farm and garden which tends to meet the more satisfactory recognized conditions of large areas of land, as well as the special wants of important growing branches of agricultural industries, is a movement in the right direction.

In repeating these statements, it is not assumed that it will

remain economical to continue the practice after a repeated application of a liberal amount of potash, without some special reason.

To restore to the soil those essential manurial constituents which the crops carry off is a safe rule to follow in the effort to secure the maintenance of the fertility of the soil; yet to obtain this result in the most economical way will always remain the ultimate aim of farming as a business enterprise.

A judicious management of the trade in commercial fertilizers implies a due recognition of results well established by experiment, regarding the requirements of a remunerative production of farm and garden crops; yet, as the manufacturer at best can only prepare the composition of his special fertilizers on general lines, not knowing the particular condition and character of the soil which ultimately receives them, it becomes of the utmost importance on the part of the farmer to make himself acquainted with his special wants of manurial substances, and to thus qualify himself for a more judicious selection from the various fertilizers offered for purchase.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the raising of farm and garden crops of every description congenial to soil and climate. The various essential articles of plant food, as potash, phosphoric acid and nitrogen compounds, are freely offered for sale in forms suitable to render, by their addition, the different kinds of manurial refuse matter of the farm in a higher degree fit to meet the special wants of the crops to be raised.

As the physical conditions and chemical resources of soils on available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised during the preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds

of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

In some cases it may be only phosphoric acid or nitrogen or potash; in others, two of them; and in others again, all three. A remunerative use of commercial fertilizers can only be secured by attending carefully to these considerations.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station at Amherst, Mass.

An economical use of manurial substances from any source is only possible after the local condition of the soil under consideration, as well as the special wants of the crops to be raised, have been duly considered. It becomes the business of every progressive farmer to acquire such information as is called for to select intelligently, from the various manurial resources at his disposal, those materials which will meet best his wants for a complete fertilizer.

In making choice from among the so-called complete fertilizers, two points seem to be in particular worth remembering. First, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to cost per ton; mere trade names are no guarantee of fitness. High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. Second, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

The majority of manufacturers and dealers in commercial fertilizers in Massachusetts have been for years on record, regarding the character of their goods, in the published re-

ports of the State inspector, which are open to the public; to these records this office invariably refers all parties asking for information in that direction.

VALUATION OF COMMERCIAL FERTILIZERS.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate market value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.	Ammoniate.
Nitrate of soda.	Castor pomace.
Muriate of potash.	Linseed meal.
Sulphate of potash.	Dried blood.
Cotton-seed meal.	Dried ground meat.
Dry ground fish.	Bone and tankage.
Azotin.	Plain superphosphates, etc.

Which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The market value of fertilizing ingredients, like other merchandise, is liable to changes during the season. The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 (Cents per Pound).

Nitrogen in ammonia salts,	13.5
Nitrogen in nitrates,	14.0
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers,	14.0
Organic nitrogen in cotton-seed meal, linseed meal and in castor pomace,	12.0
Organic nitrogen in fine-ground bone and tankage,	13.5
Organic nitrogen in medium-ground bone and tankage,	11.0
Organic nitrogen in coarse bone and tankage,	8.0
Phosphoric acid soluble in water,	5.5
Phosphoric acid soluble in ammonium citrate,	5.0
Phosphoric acid in fine bone and tankage,	5.0
Phosphoric acid in medium bone and tankage,	4.0
Phosphoric acid in coarse bone and tankage,	2.5
Phosphoric acid in fine-ground fish, cotton-seed meal, linseed meal, castor pomace and wood ashes,	5.0
Phosphoric acid insoluble (in am. cit.) in mixed fertilizers,	2.0
Potash as sulphate, free from chlorides,	5.0
Potash as muriate,	4.5

From these figures it is apparent that the best forms of nitrogen and phosphoric acid have suffered a material reduction in cost, as compared with preceding years.

The market value of low-priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barn-yard manure, factory refuse and waste materials of various description, quite frequently does not stand in a close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation, and more or less advantageous mechanical conditions for speedy action, exert, as a rule, a decided influence on their selling price.

The mechanical condition of any fertilizing material, simple or compound, deserves the most serious consideration of farmers when articles of a similar chemical character are

offered for their choice. The degree of pulverization controls, almost without exception, under similar conditions, the rate of solubility, and the more or less rapid diffusion of the different articles of plant food throughout the soil.

The state of moisture exerts a no less important influence on the pecuniary value in case of one and the same kind of substance. Two samples of fish fertilizers, although equally pure, may differ from fifty to one hundred per cent. in commercial value, on account of mere difference in moisture.

Crude stock for the manufacture of fertilizers, and refuse materials of various descriptions, have to be valued with reference to the market price of their principal constituents, taking into consideration at the same time their general fitness for speedy action.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see to it that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties. The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home consumption, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the sale of Commercial Fertilizers in the State during the Past Year (May 1, 1897, to May 1, 1898) and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

American Fertilizer Co., Boston, Mass.: —
- Alkali Nitrate Phosphate for Hoed Crops.

American Fertilizer Co. — *Con.*
- Alkali Nitrate Phosphate for Grass and Grain.
- General American Fertilizer.
- Potato Fertilizer.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.
- Animal Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Bartlett & Holmes, Springfield, Mass. : —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

H. J. Baker & Bro., New York, N. Y. : —
- Pure Ground Bone.
- Standard Un X Ld Fertilizer.
- Strawberry Manure.
- Potato Manure.
- Tobacco Manure.
- Grass and Grain Manure.
- A. A. Ammoniated Superphosphate.
- Harvest Home Fertilizer.

C. A. Bartlett, Worcester, Mass. : —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport, Conn. : —
- Complete Fertilizers.
- Ammoniated Bone Phosphate.

Bowker Fertilizer Co., Boston, Mass. : —
- Stockbridge Special Manures.
- Hill and Drill Phosphate.
- Farm and Garden Phosphate.
- Lawn and Garden Dressing.
- Fish and Potash.
- Potato and Vegetable Manure.
- Potato Phosphate.
- Market Garden Manure.
- Sure Crop Phosphate.
- Gloucester Fish and Potash.
- High-grade Fertilizer.
- Essex Fertilizer.
- Bone and Wood Ash Fertilizer.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.

William E. Brightman, Tiverton, R.I. : —
- Potato and Root Manure.
- Phosphate.
- Fish and Potash.

Bradley Fertilizer Co., Boston, Mass. : —
- X. L. Superphosphate.
- Potato Manure.
- B. D. Sea Fowl Guano.
- Complete Manures.
- Fish and Potash.
- High-grade Tobacco Manure.
- English Lawn Fertilizer.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.

Bradley Fertilizer Co. — *Con.*
- Muriate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.
- Fine-ground Bone.

Daniel T. Church, Providence, R.I. (E. Wilcox, general agent) : —
- Church's B Special.
- Church's C Standard.
- Church's D Fish and Potash.

The Cleveland Linseed Oil Co., Cleveland, O. : —
- Screened Linseed Meal.

Clark's Cove Fertilizer Co., Boston, Mass. : —
- Bay State Fertilizer.
- Bay State Fertilizer G. G. Brand.
- Great Planet Manure.
- Potato and Tobacco Fertilizer.
- King Philip Guano.
- Potato Manure.
- Fish and Potash.
- White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass. : —
- Superphosphate.
- Potato Phosphate.
- Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y. : —
- High-grade Potato Fertilizer.
- Bay State Ammoniated Bone Superphosphate.
- Bay State Potato Manure.
- High-grade Ammoniated Bone Superphosphate.
- Gold Brand Excelsior Guano.
- Fish Guano and Potash.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y. : —
- Ammoniated Bone Superphosphate.
- Potato, Hop and Tobacco Phosphate.
- Ammoniated Wheat and Corn Phosphate.
- New Rival Ammoniated Superphosphate.
- Practical Ammoniated Superphosphate.
- Vegetable Bone Superphosphate.
- General Crop Phosphate.
- Universal Grain Grower.
- Special Potato Manure.
- New England Tobacco and Potato Grower.

Crocker Fertilizer and Chemical Co. — *Con.*
Coolidge Bros. Special Truck Fertilizer.
A. A. Complete Manure.
Ground Bone Meal.
Pure Ground Bone.
Muriate of Potash.
Nitrate of Soda.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Superphosphate.
Potato Fertilizer.
Concentrated Phosphate.
Guano.

City Florist, Brockton, Mass.: —
Boo Boo Plant Food.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
Animal Fertilizer.
Potato and Root Crop Manure.
Lawn Dressing.
Tobacco Grower.
Blood, Bone and Potash.
Special Formula.
Fine-ground Bone.
Muriate of Potash.
Nitrate of Soda.

John C. Dow & Co., Boston, Mass.: —
Ground Bone Fertilizer.
Nitrogenous Superphosphate.
Pure Ground Bone.

W. E. Fife & Co., Clinton, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Northern Corn Special.
General Fertilizer.
Vegetable Vine and Tobacco Fertilizer.
Garden Special.
Soluble Bone and Potash.

Thomas Hersom & Co., New Bedford, Mass.: —
Bone Meal.
Meat and Bone.

Alonzo P. Henderson, Hanover, Mass.: —
Acme Brand Fertilizer.

Edmund Hersey, Hingham, Mass.: —
Ground Bone.

John G. Jefferds, Worcester, Mass.: —
Animal Fertilizer.
Potato Manure.
Fine-ground Bone.

Thomas Joint, St. Helen, Ontario, Can.: —
Unleached Hard-wood Ashes.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

A. Lee & Co., Lawrence, Mass.: —
Lawrence Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
Bone Fertilizer for Corn and Grain.
Complete Manure for Vegetables.
Animal Fertilizer.
Potato Phosphate.
Bone and Potash.
Lawn Dressing.
Tobacco Manure.
Empire Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass.: —
Tankage.

F. L. Lalor, Dunville, Ontario, Can.: —
Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
Bone Manures.
Superphosphates.
Special Crop Manures.
Sulphate of Potash.
Double Manure Salts.
Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can.: —
Unleached Hard-wood Ashes.

McQuade Bros., West Auburn Mass.: —
Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y.: —
Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
Complete Fertilizers.
Ammoniated Bone.

National Fertilizer Co. — *Con.*
Market-garden Manure.
Potato Phosphate.
Fish and Potash.
Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
Wheat and Corn Producer.
Grain and Grass Grower.
Potato, Tobacco and Hop Fertilizer.
Niagara Triumph.

New England Dressed Meat and Wool Co., Boston, Mass.: —
Sheep Fertilizer.

Packers Union Fertilizer Co., New York, N. Y.: —
Universal Fertilizer.
Wheat, Oats and Clover Fertilizer.
Animal Corn Fertilizer.
Potato Manure.
Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass: —
Soluble Pacific Guano.
Special Potato Manure.
Special for Potatoes and Tobacco.
Nobsque Guano.
High-grade General Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Plymouth Rock Brand.
Star Brand Fertilizer.
Butman Brand Fertilizer.
Special Potato.
Strawberry.
Ground Bone.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.

A. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
Complete Manures.
Phosphate.
Nitrate of Soda.
Muriate of Potash.
Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
Ammoniated Bone Superphosphate.

Quinnipiac Co., Boston, Mass.: —
Phosphate.
Potato Manure.
Market-garden Manure.
Fish and Potash.
Havana Tobacco Grower.
Grass Fertilizer.
Corn Manure.
Potato Phosphate.
Onion Manure.
Pure Ground Bone.
Dry Ground Fish.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.
Sulphate of Ammonia.
Dissolved Bone-black.

Read Fertilizer Co., New York, N. Y. (H. D. Foster, general agent): —
Standard Fertilizer.
High-grade Farmers' Friend.
Practical Potato Special.
Farmer's Friend,
Vegetable and Vine.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

The Rogers & Hubbard Co., Middletown, Conn.: —
Soluble Potato Manure.
Soluble Tobacco Manure.
Fairchild's Formula for Corn and General Crops.
Fruit Fertilizer.
Grass and Grain Fertilizer.
Oats and Top-dressing Fertilizer.
Pure Raw Knuckle Bone Flour.
Strictly Pure Fine Bone.
Fertilizer for all Soils and all Crops.

Russia Cement Co., Gloucester, Mass.:—
X X X Fish and Potash.
High-grade Superphosphate.
Corn, Grain and Grass Manure.
Potato, Root and Vegetable Manure.
Special Tobacco Fertilizer.
Odorless Lawn Dressing.

Lucien Sanderson, New Haven, Conn.:—
Formula A.
Blood, Bone and Meat.
Dissolved Bone-black.
Nitrate of Soda.
Sulphate of Potash.
Muriate of Potash.

Edward H. Smith, Northborough, Mass.: —
Ground Bone.

J. Stroup & Son Co., Boston, Mass.: —
Hard-wood Ashes.

Thomas L. Stetson, Randolph, Mass.:—
Ground Bone.

Standard Fertilizer Co., Boston, Mass.:—
Standard Fertilizer.
Potato and Tobacco Fertilizer.
Standard Guano.
Complete Manure.
Fine-ground Bone.

C. F. Sturtevant, Hartford, Conn: —
Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.

I. P. Thomas & Son Co., Philadelphia, Pa.: —
Martin's Bone Mixture.
So. Carolina Phosphate with Potash.
So. Carolina Phosphate.
Pure Ground Animal Bone.
Steamed Bone.
Improved Superphosphate.
Potato and Tomato Manure.
Normal Bone Phosphate.
Farmer's Choice Bone Phosphate.
Tobacco Fertilizer.

Walker, Stratman & Co., Pittsburg, Pa.: —
Potato Special.
Big Bonanza.
Smoky City.
Four Fold.

Andrew H. Ward, Boston, Mass.: —
Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
Complete Manure.

D. Whithed, Lowell, Mass.: —
Champion Fertilizer.
Bone Meal.

The Wilcox Fertilizer Works, Mystic Conn.: —
Potato, Onion and Tobacco Manure.
Ammoniated Bone Phosphate.
High-grade Fish and Potash.
Dry Ground Fish Guano.

Williams & Clark Fertilizer Co., Boston, Mass.: —
Ammoniated Bone Superphosphate.
Potato Phosphate
High-grade Special.
Fine Wrapper Tobacco Grower.
Royal Bone Phosphate.
Corn Phosphate.
Potato and Tobacco Manure.
Grass Manure.
Fish and Potash.
Universal Ammoniated Dissolved Bone.
Prolific Crop Producer.
Onion Manure.
Bone Meal.
Dry Ground Fish.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Dissolved Bone-black.
Sulphate of Ammonia.

M. E. Wheeler & Co., Rutland, Vt.: —
High-grade Corn Fertilizer.
High-grade Potato Manure.
Superior Truck Fertilizer.
Havana Tobacco Grower.
High-grade Fruit Fertilizer.
High-grade Grass and Oats Fertilizer.
Electrical Dissolved Bone.

II. REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Barn-yard Manure.
3. Notes on Wood Ashes.
4. Notes on Cotton-seed Meal.
5. Notes on Guano from West Coast of Africa.
6. Notes on Ashes from Crematory Furnace for City Garbage.
7. Notes on Wool Washings.

1. Analyses of Materials sent on for Examination.

The work carried on in this connection is growing from year to year in importance. A large proportion of commercial manurial substances consists of by or waste products of various industries. The composition and general character of these materials depend on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers to the full extent of the resources placed at the disposal of the officer in charge of this work. These investigations are carried on free of charge to farmers of the State. The results are considered public property, and are published from time to time in the bulletins of the station.

The number of substances tested in this connection amount to two hundred and thirty-eight. As the detailed results of

their analyses have already been published in three bulletins, Nos. 45, 48 and 49, March, July and November, 1897, a brief statement of the names of the different articles analyzed will, on this occasion, suffice to convey some idea of the extent and the character of the work accomplished. Only a few of these materials of more special importance are reserved for a subsequent short discussion.

The substances tested from Dec. 1, 1897, to Dec. 1, 1898, are as follows: wood ashes, 89; cotton-seed meal, 23; cotton-seed hull ashes, 3; cotton factory waste, 5; tankage, bone and fish, 17; muck, peat and soils, 16; chemicals, 14; acid phosphates and dissolved bone-blacks, 5; natural phosphates, 6; tobacco refuse, 2; complete fertilizers, 31; miscellaneous, 9; Damara land guano, garbage cremation ashes and wool washings, each 1.

Aside from this work are the complete analyses of 36 samples of tobacco leaves, together with numerous tests for the quality of ash and rate of combustion. See Bulletin No. 47, on tobacco experiments, published in April, 1897.

The responsibility of the genuineness of all articles sent on for examination rests with the parties asking for the analysis. Our publications of the results refer merely to the locality they come from, to avoid misunderstandings. Samples of fertilizers collected from original packages by authorized agents of the station in the general markets furnish the material for official analyses, and are considered genuine articles.

2. Notes on Barn-yard Manure.

The importance of barn-yard manure as a home source of plant food cannot be over-estimated in a mixed farm management. In a well-regulated rational system of stock feeding it is one of the cheapest if not the cheapest source of valuable manurial constituents. An exceptional liability to vary in composition is the strongest objection which can be raised against its exclusive use as a manure supply for the farm and garden, yet this objection has lost much of its force since the causes of variation are better understood, and may thus be avoided to a considerable extent. We have learned

how to improve its efficiency as a complete manure under varying conditions of soil as well as of varying wants of crops, by adding those manurial constituents which are called for in different relative proportions, and which the barn-yard manure on hand does not contain.

Analyses of Eighty Samples of Barn-yard Manure made at Amherst, Mass.

ANALYSIS.	Pounds per Hundred. Highest.	Lowest.	Average.	Pounds per Ton (2,000 Pounds).
Moisture,	75.00	60.00	67.24	1344.80
Nitrogen,	1.36	.21	.52	10.40
Potassium oxide,	1.40	.13	.56	11.20
Phosphoric acid,	.75	.10	.39	7.80

The average barn-yard manure contains, as will be noticed from the above statement, a larger percentage of nitrogen as compared with potash and phosphoric acid than is generally considered economical in a complete fertilizer for general farm purposes.

The practice of adding to the manurial refuse materials of the farm, as stable manure, vegetable compost, etc., such single commercial manurial substances as will enrich them in the direction desirable for any particular crop, does not yet receive that degree of general attention which it deserves. An addition of potash in the form of muriate or sulphate of potash, or of phosphoric acid in the form of fine-ground South Carolina or Florida soft phosphate, etc., will in many instances not only improve their general fitness as complete manure, but quite frequently permit a material reduction in the amount of barn-yard manure ordinarily considered necessary to secure satisfactory results. An addition of from thirty to forty pounds of muriate of potash and one hundred pounds of fine-ground soft Florida phosphate per ton of barn-yard manure, at any time before applying the latter to the soil deserves recommendation.

3. Notes on Wood Ashes.

Forty per cent. of all articles sent on for examination consist of wood ashes. They are sold in the majority of cases under the trade name "Unleached Canada hard-wood ashes." Ninety-eight samples tested at the station during the past year gave the following results: —

	No. of Samples.
Moisture from 1 to 3 per cent.,	10
" 4 to 6 "	8
" 6 to 10 "	13
" 10 to 15 "	19
" 15 to 20 "	11
" 20 to 30 "	10
Moisture above 35 per cent.,	1
Potassium oxide above 8 per cent.,	3
" " from 7 to 8 per cent.,	8
" " " 6 to 7 "	21
" " " 5 to 6 "	28
" " " 4 to 5 "	10
" " " 3 to 4 "	3
" " below 3 per cent.,	none
Phosphoric acid above 2 "	4
" " from 1 to 2 per cent.,	45
" " below 1 per cent.,	24
Average per cent. of calcium oxide (lime),	34.29
Per cent. mineral matter insoluble in diluted hydrochloric acid, from — 6 to 10,	10
10 to 15,	30
15 to 20,	15
20 to 30,	3
above 30,	1

The variations noticeable in the composition of wood ashes are not surprising when we consider the crude mode of collecting and handling them for commercial purposes. The particular effects of both varying quantities of foreign insoluble matter, as soil, coal ashes, etc., and of moisture, on the composition of a given sample of genuine wood ashes, as far as its percentage of potash and of phosphoric acid is concerned, depend largely on the particular kind of wood which has served for the production of the ash. The color of the wood ashes in case of dark varieties depends usually on admixture of more or less charcoal, while an exceptionally light color is not unfrequently due to the kind of wood which furnishes it. Some kinds of wood, as elm

wood, produce a white ash of excellent quality, judging from samples sent on for examination.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid.

Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and foreign matters are apt to affect seriously the weight of a given measure.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

4. Notes on Cotton-seed Meal as a Fertilizer.

Recent low prices of some concentrated feed stuffs have favored experiments to test their fitness for supplying directly nitrogen, phosphoric acid and potash for plant food. Whenever the market value of the amount of nitrogen, phosphoric acid and potash they contain compares fairly well with the market cost of these three ingredients, the trials deserve, for various reasons, encouragement.

The richness of cotten-seed meal, linseed meal, etc., as well as their marked disposition to rot in the presence of

moisture and of a fair average temperature, caused their selection. Both are quite frequently looked upon with favor as suitable materials to furnish plant food for various farm crops. Cotton-seed meal in particular is to-day used extensively by tobacco growers in the Connecticut River valley as the main source of nitrogen for that crop.

The increasing importance of cotton-seed meal as a fertilizer has been followed by the writer with a frequent examination of the articles sold in our markets to protect the interests of our farmers. Importers of cotton-seed meal, claiming that they sold their articles as a feed stuff and not as a fertilizer, declined as a rule until quite recently to take out a fertilizer license which would oblige them to sell with a stated guarantee of at least the nitrogen.

The results of sixty-five analyses carried on under my direction are as follows: —

	Per Cent.		
	Maximum.	Minimum.	Average.
Moisture,	10.80	3.90	7.00
Nitrogen,	7.95	2.08	6.60
Phosphoric acid,	3.36	.73	1.79
Potassium oxide,	2.38	.48	1.76

Allowing 12 cents for every pound of nitrogen, 5 cents per pound for each of phosphoric acid and potassium oxide, these three ingredients represent per ton a market value of —

$19.39 in case of our average sample of cotton-seed meal.
24.82 in case of our highest sample of cotton-seed meal.
6.20 in case of our lowest sample of cotton-seed meal.

The above-stated difference in the composition of cotton-seed meal is mainly due to the presence of more or less ground skins and husks of the cotton seed. Cotton-seed meal designed for fodder ought to be free from skins and husks, to deserve a recommendation for that purpose; cotton-seed meal to be used for fertilizer may contain more or

less of this substance, provided the entire material is finely ground and the price in accordance with the composition.

We advise farmers to buy cotton-seed meal, like all other fertilizing materials, on the basis of a guarantee of (at least) nitrogen as the basis of the bargain. For their information it seems but proper to state in this connection that the American Cotton Oil Company of New York has quite recently secured a license for the sale of their cotton-seed meal as a fertilizer in our State, and intend to sell on the basis of the amount of nitrogen their article contains.

5. Notes on Damara Land Guano.

The material which served for our examination was sent on to this office by Messrs. H. J. Baker & Bro. of New York City. It consisted of a bag containing two hundred pounds of guano, and was accompanied by analyses of two chemists of London, Eng. As every new source of a genuine guano claiming to resemble the Peruvian guano of earlier periods in the trade of commercial fertilizers must be of special importance to all interested in the temporary resources of our supplies of plant food, our results are briefly stated below: —

Analysis of Damara Land Guano (Per Cent.).

Moisture at 100° C.,	17.70
Organic matter,	25.63
Total ash,	56.67
Total nitrogen,	5.79
Nitrogen in form of ammoniates,	1.80
Nitrogen in form of nitrates,	.05
Nitrogen in form of organic matter,	3.94
Carbonic acid,	trace
Total phosphoric acid,	14.78
Soluble phosphoric acid,	4.90
Reverted phosphoric acid,	5.79
Insoluble phosphoric acid,	4.09
Total potassium oxide,	3.53
Potassium oxide soluble in water,	3.46
Sodium oxide,	7.03
Calcium oxide,	14.21
Magnesium oxide,	2.05
Iron and aluminum oxides,	trace
Sulphuric acid,	5.94
Chlorine,	5.77
Insoluble matter,	9.26

The results of our analyses of the sample (two hundred pound bag) kindly sent on for trial by Messrs. H. J. Baker & Bro., New York City, are fairly within the stated composition of English chemists. The guano, it is stated, has been brought from some islands off the west coast of Africa; it is a valuable material, as may be seen from our detailed statement.

6. Notes on Crematory Ashes from City Garbage.

In my annual report for 1895 (pages 160 and 161), special attention was called to two important recent modes of saving city garbage, kitchen refuse in particular, for manurial purposes. Sanitary considerations are the first cause of the introduction of these new modes of disposing of objectionable refuse matter, which promise to become from day to day more important as supplies of valuable fertilizer materials.

Our attention has been in particular called to the products of the crematory furnace ashes from Lowell, Mass. The article is evidently improving, in consequence of the adoption of a proper system of sifting and grinding the ashes, as will be seen from the accompanying analysis, representing, according to statement, one hundred tons. The selling price, from $10 to $11 per ton, invites serious trials, as a fertilizer furnishing potash, phosphoric acid and lime.

Analysis of Ashes from the Cremation of City Garbage (Per Cent.).

Moisture at 100° C.,	.53
Potassium oxide,	6.01
Sodium oxide,	15.65
Total phosphoric acid,	10.21
Available phosphoric acid,	2.34
Insoluble phosphoric acid,	7.87
Sulphuric acid (So_3),	4.57
Chlorine,	4.75
Carbonic acid (CO_2),	10.85
Calcium oxide,	20.22
Magnesium oxide,	1.16
Iron and alumina,	9.32
Insoluble matter,	24.26
Nitrogen (inactive lyan compounds),	.17

7. Notes on Wool Washings as a Source of Fertilizer.

It is a well-known fact that the skins of sheep and raw wool are coated with potash compounds of a soap-like nature. In many localities in Europe it is a common practice to turn to account for manuring grass lands the water used in washing sheep before shearing, as well as the wash water obtained from raw wool in factories. This is used in form of an overflow. Wherever meadows adjoin the place of washing wool, arrangements may be readily provided for turning the wool washings directly to account. Samples of raw wool tested here for potash some years ago gave the following results: —

Potassium oxide soluble in water (per cent.),	3.92
Potassium oxide soluble in diluted hydrochloric acid (per cent.),	4.20

Of interest in this connection are the results of examination of a material sent on from a factory in this State. The article was labelled "concentrated potash liquor," and described as obtained from the washings of wool with water after the grease had been extracted by naphtha. It consisted of a highly colored, thick, syrup-like mass, containing a liberal admixture of fine fibrous vegetable matter. An analysis made with reference to its approximate value as a fertilizer gave the following results: —

	Per Cent.
Moisture at 100° C.,	41.13
Dry matter,	58.87

The dry matter left behind contained: —

	Per Cent.
Potassium oxide,	10.15
Phosphoric acid,	.10
Nitrogen,	1.09

The commercial value of these ingredients per ton of the original substance at the present rates amounts approximately to $12.40. In charring the original material directly, 100 parts left behind 36.49 parts; the charred mass tested for potassium oxide showed 34.91 per cent. present, or 698.2 pounds of potassium oxide per ton of charred residue, which

equals 1,012 pounds of carbonate of potash per ton of charred residue practically free from chlorine.

The scarcity of a good quality of carbonate of potash for manurial purposes in case of tobacco and similar industrial crops ought to encourage attempts to turn the concentrated potash liquor to account.

The charred mass might serve directly as material for the manufacture of a high-grade potash fertilizer.

III. NOTES OF FIELD EXPERIMENTS WITH TOBACCO IN MASSACHUSETTS, 1893–96.

CHARLES A. GOESSMANN.

The experiments briefly described in the following pages were carried on with the co-operation of the Valley Tobacco Experiment Association of Massachusetts.

The officers of this organization consisted of President L. A. Crafts of Whately, Vice-President C. L. Fowler of Westfield, Secretary and Treasurer G. D. Fisk of Agawam; Board of Directors, W. A. Porter of Agawam and C. L. Warner of Hatfield.

Hatfield, Westfield and Agawam were chosen for the location of the experiments. The selection of the particular field in each place was left to a special committee of the association. In all cases a deep, sandy loam was selected for the trial.

The same kind and the same amount of fertilizing ingredients were used in all cases, and the observations continued for three successive years. For details see Bulletin No. 47, April, 1897.

The variety of tobacco selected for the trial was Havana seed. For the purpose of securing uniformity of fertilizer during the years of the experiment, it was decided to purchase at once, as far as advisable, enough of each kind to supply the needed materials for three years.

Statement of Fertilizers used upon Different Plots.

The fertilizer mixture used during the entire time of observation contained in all cases, per acre: —

	Pounds.
Potassium oxide (available)	300
Nitrogen (available),	100
Phosphoric acid (available),	60

One-fourth of the nitrogen was in all cases used in the form of nitrates of soda or potash, to secure a uniform con-

dition of availability of nitrogen during the early stages of growth.

Each experiment plot measured 3,634 square feet, or approximately one-twelfth of one acre.

Chemical Composition of the Different Fertilizing Ingredients used in compounding the Special Fertilizers for Different Plots in the Tobacco Experiment. Ingredients containing Chlorine were carefully excluded from the Mixtures of Fertilizers in All Cases.

NAME OF MATERIAL.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.
Nitrate of soda, ...	15.59	–	–	35.00	–	–
Nitrate of potash, ...	12.79	–	45.05	–	–	–
Cotton-seed meal, ...	6.50	3.17	2.25	–	–*	–*
Linseed meal, ...	5.91	1.95	1.08	–	–*	–*
Castor pomace, ...	5.60	2.26	3.40	–	–*	–*
Dissolved bone-black, ...	–	13.38	–	–	–*	–
Odorless phosphate, or phosphatic slag,	–	18.42	–	–	48.27	–
High-grade sulphate of potash, . .	–	–	50.20	–	–	–
Potash-magnesia sulphate, . . .	–	–	24.32	–	–	12.58
Cotton-seed hull ashes, ...	–	7.93	23.96	–	9.30	10.47
Carbonate of potash-magnesia, . .	–	–	18.48	–	–	19.52
Barn-yard manure, ...	.52	.39	.56	–*	–*	–*

* Not determined.

Chemical Composition of the Different Special Formulas used in the Tobacco Experiment.

PLOT 1.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash, ...	195	–	88	25
Cotton-seed meal, ...	1,154	37	26	75
Dissolved bone-black, . . .	175	23	–	–
Potash-magnesia sulphate, . .	765	–	186	–
Total, ...	–	60	300	100

PLOT 2.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash,	195	–	88.0	25
Castor pomace,	1,340	31	45.0	75
Dissolved bone-black,	221	29	–	–
Potash-magnesia sulphate,	685	–	166.5	–
Total,	–	60	299.5	100

PLOT 3.

Nitrate of soda,	160.3	–	–	25
Cotton-seed meal,	1,154.0	37.00	26	75
Cotton-seed hull ashes,	1,142.0	90.56	274	–
Total,	–	127.56	300	100

PLOT 4.

Nitrate of soda,	160.3	–	–	25
Castor pomace,	1,340.0	31.0	45.50	75
Cotton-seed hull ashes,	1,060.0	84.1	253.97	–
Total,	–	115.1	299.47	100

[PLOT 5.—No manure at any time during the experiment.]

PLOT 6.

Nitrate of soda,	160.3	–	–	25
Cotton-seed meal,	1,154.0	37	26	75
Dissolved bone-black,	175.0	23	–	–
High-grade sulphate of potash,	545.8	–	274	–
Total,	–	60	300	100

PLOT 7.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of soda, ...	160.3	–	–	25
Castor pomace, ...	1,340.0	31	45.50	75
Dissolved bone-black, . . .	221.0	29	–	–
High-grade sulphate of potash, .	506.0	–	254.50	–
Total, ...	–	60	300.00	100

PLOT 8.

Nitrate of soda, ...	160.3	–	–	25
Linseed meal, ...	1,271.0	24.78	14	75
Dissolved bone-black, . . .	263.0	35.22	–	–
High-grade sulphate of potash, .	569.7	–	286	–
Total, ...	–	60.00	300	100

PLOT 9.

Nitrate of potash, ...	195	–	88	25
Cotton-seed meal, ...	1,154	37	26	75
Cotton-seed hull ashes, . . .	776	62	186	–
Total, ...	-	99	300	100

PLOT 10.

Nitrate of potash, ...	195.0	–	88.00	25
Castor pomace, ...	1,340.0	31	45.50	75
Phosphatic slag meal, . . .	157.0	29	–	–
Carbonate of potash-magnesia, .	900.9	–	166.50	–
Total, ...	–	60	300.00	100

PLOTS 11 AND 12.*

Barn-yard manure, ...	20,000	78	112	104

* Average analysis of seventy-five samples tested at the station laboratory at Amherst, Mass.

Summary of Three Years of Observation at Hatfield, Agawam and Westfield.

I. *Number of Plants harvested and Yield of Tobacco per One Thousand Plants.*

Hatfield (Old Tobacco Land).

Year.	Average Number of Plants.		Difference in Yield per Plot on the Basis of 1,000 Plants (Pounds).	
	Per Plot.*	Per Acre.	Highest.	Lowest.
1893,	561	6,734	266	217
1894,	618	7,419	223	191
1895,	626	7,512	222	191

* One-twelfth of one acre.

Westfield (New Tobacco Land).

Year.	Per Plot.	Per Acre.	Highest.	Lowest.
1894,	670	8,040	192	155
1895,	593	7,122	245	217
1896,	689	8,269	216	191

Agawam (New Tobacco Land).

Year.	Per Plot.	Per Acre.	Highest.	Lowest.
1893,	696	8,352	225	158
1894,	704	8,432	220	164
1895,	695	8,340	222	148

Year.	Average Yield of Tobacco on the Basis of 1,000 Plants Harvested (Pounds).		
	Hatfield.	Westfield.	Agawam.
1893,	235.2	–	191.3
1894,	206.4	171.6	186.7
1895,	210.5	228.0	176.2
1896,	–	199.4	–

II. Average Yield of Tobacco, with Reference to Wrapper, per One Thousand Plants.

Hatfield.

YEAR.	Average Yield of Tobacco.	Average Yield of Wrappers.	Average Percentage of Wrappers.	Variations in Percentage of Wrappers in Plots.
	Pounds.	Pounds.		
1893, ...	235.2	97.2	41.2	21.0-71.0
1894, ...	206.6	105.0	50.7	38.8-64.4
1895, ...	210.1	109.3	52.1	36.8-63.1

Westfield.

1894, ...	171.3	90.3	52.3	41.6-62.10
1895, ...	228.7	49.6	21.2	6.4-34.40
1896, ...	199.3	138.2	69.6	59.0-78.80

Agawam.

1893, ...	190.8	–*	–*	–*
1894, ...	191.7	52.2	26.7	8.8-44.4
1895, ...	178.8	–*	–*	–*

* Not determined.

Conclusions drawn from the Third Year of Observation.

1. Good mechanical preparation of the soil and early application, and thus good diffusion of the fertilizers, not less than early planting and a suitable number of plants to a given area, exert a decided influence on the quantity and the quality of the crop, under otherwise corresponding conditions. Planting as early as the local climate admits secures the benefit of the winter moisture.

Too close planting interferes with a liberal or rapid development of the leaves, and too large open spaces between the

individual plants tends to favor a coarser structure. Rows three feet and four inches apart with plants twenty inches from each other in the row (Westfield), and rows two feet and eight inches apart with plants two feet from each other in the row (Hatfield) gave better returns than rows three feet apart with plants eighteen inches from each other in the row (Agawam).

2. A timely, shallow use of the cultivator or hoe for the removal of weeds favors a uniform progress of growth. A careless use of cultivator or hoe invariably checks more or less the growth of the plants, and modifies more or less their structure and general character.

3. The different fertilizer mixtures used in our experiments have affected in a less marked degree the weight of the crop raised by their aid than the quality. New lands reduced by previous cropping to a state approaching general exhaustion of available plant food, if otherwise well fitted for raising tobacco, have given excellent results when supplied with a suitable mixture of fertilizing ingredients in quantities similar to those applied during our experiments (Westfield). Such lands are at times preferable to old tobacco lands overcharged with remnants of all kinds of saline ingredients, usually associated with the common run of commercial fertilizers.

4. Cotton-seed meal, linseed meal and castor pomace have proved equally good sources of nitrogen for the successful raising of tobacco when used in connection with nitrate of soda or potash, sufficient to furnish one-fourth of the nitrogen called for by the crop.

5. Nitrate of soda as a part of the nitrogen supply in the fertilizer (25 per cent.), when used in presence of acid phosphate, dissolved bone-black, etc., has been accompanied with better results regarding quality of crop than nitrate of potash under otherwise similar conditions.

6. Cotton-seed hull ashes and high-grade sulphate of potash have proved in our observation most valuable sources of potash for tobacco, the former in the majority of cases leading. Nitrate of potash has produced excellent results when used in connection with an alkaline phosphate, as phosphatic slag meal or with carbonate of potash-magnesia. Our

results with potash-magnesia sulphate as the main potash sources of a tobacco fertilizer are not encouraging.

7. The difference noticed in the color of ash, etc., in case of the crop being raised upon different plots, is in several instances so slight that an attempt to classify the various fertilizers used with reference to their superior fitness on the basis of color and compactness of ash cannot be otherwise than arbitrary. With this qualification in mind, the following classification is offered for the consideration of parties engaged in the cultivation of tobacco in our section of the country: —

First Class.

Plot 4. — Nitrate of soda, cotton-seed hull ashes and castor pomace.

Plot 3. — Nitrate of soda, cotton-seed hull ashes and cotton-seed meal.

Plot 9. — Nitrate of potash, cotton-seed hull ashes and cotton-seed meal.

Plot 10. — Nitrate of potash, carbonate of potash-magnesia and phosphatic slag.

Second Class.

Plot 6. — Nitrate of soda, high-grade sulphate of potash, cotton-seed meal and dissolved bone-black.

Plot 8. — Nitrate of soda, high-grade sulphate of potash, linseed meal and dissolved bone-black.

Plot 7. — Nitrate of soda, high-grade sulphate of potash, castor pomace and dissolved bone-black.

Third Class.

Plot 1. — Nitrate of potash, potash-magnesia sulphate, cotton-seed meal and dissolved bone-black.

Plot 2. — Nitrate of potash, potash-magnesia sulphate, castor pomace and dissolved bone-black.

The observations with barn-yard manure have not been considered in the above classification; they are very encouraging, but not sufficient in number to permit detailed discussion in this connection; besides, the amount of barn-yard manure used in our experiment, ten tons per acre, contained nearly two hundred pounds of potassium oxide and

from thirty to forty pounds of available phosphoric acid less than our formula of commercial fertilizing ingredients called for.

An early application of barn-yard manure, properly supplemented with a suitable potash compound and available phosphoric acid, has produced excellent results in other localities.

INDEX.

PUBLIC DOCUMENT . . . . No. 33.

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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B.Sc.,	*Assistant Entomologist.*
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 37. Report on fruits, insecticides and fungicides.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
No. 50. The feeding value of salt-marsh hay.
No. 51. Fertilizer analyses.
No. 52. Variety tests of fruits; spraying calendar.
No. 53. Concentrated feed stuffs.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 56. Concentrated feed stuffs.
No. 57. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can only be supplied to complete sets for libraries.

New methods and new appliances in the feeding and care of animals and plants have opened up new problems, and the demands made upon the station have taxed it to its uttermost. Briefly summarizing the work of the year, we find it distributed as follows: in the division of foods and feeding a new feature has been added, viz., regulating the sale of concentrated feed stuffs. There have been 663

analyses of these materials made, 292 of fodder and 420 of dairy products. In an investigation of Cleveland flax meal *v.* old-process linseed meal for feeding early lambs, it was found that no injurious results followed from the use of flax meal, and that there was the same average daily growth of the lambs on either ration; in an experiment of corn meal *v.* hominy meal and corn meal *v.* cerealine feed for growing pigs, it was found that the corn meal was five to ten per cent. more valuable than cerealine feed used in connection with skim-milk, while hominy meal was quite as valuable as corn meal in connection with skim-milk.

In the entomological division, besides the special work in connection with the gypsy moth, attention has been paid to combining the arsenate of lead and the Bordeaux mixture, with favorable results. The life histories and habits of two pernicious insects have been worked out, — the grass thrips, particularly destructive in this State, and the small clover-leaf beetle (*Phytonomus nigrirostris*). The pernicious scale insects (*Chionaspis*) have also been carefully studied, and the results will soon be published.

The horticultural division has continued its work of testing varieties of fruits, domestic and foreign, suitable for this State, and its investigation of hydrocyanic acid as an insecticide.

The division of fertilizers has made five hundred and fifty-two analyses; has conducted experiments on the use of concentrated chemical manures to supply plant food in greenhouses, combinations of high-grade fertilizers for garden, greenhouse and pot cultivation; and has made observations with dried blood and two kinds of leather refuse as a source of nitrogen for growing rye in presence of acid and alkaline phosphates.

The agricultural division, in addition to its soil tests with corn, onions, oats, etc., has undertaken the testing of seeds of the same variety of potatoes raised in different localities, finding a variation of fifty per cent. in Early Rose and Beauty of Hebron. In experiments with poultry the following results were obtained with reference to egg production: (*a*) that condition powders had no effect; (*b*) that

animal meal was of more value than cut bone; (*c*) that the influence of the cock was *nil;* (*d*) that a wide ration was preferable to a narrow ration.

The botanical division has issued an illustrated bulletin (No. 55) on the nematode worm, in which its life history is traced, and a simple remedy, steaming the soil, given for its repression. Work has been done in the drop and top burn of lettuce, asparagus and chrysanthemum rust, and in sub-irrigation and the mechanical condition of soil as affecting the growth of lettuce.

Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1898.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,443 00	
for labor,	3,605 36	
for publications,	2,885 54	
for postage and stationery,	235 56	
for freight and express,	355 49	
for heat, light and water,	130 17	
for seeds, plants and sundry supplies,	448 72	
for fertilizers,	285 86	
for feeding stuffs,	141 17	
for library,	244 78	
for tools, implements and machinery,	250 00	
for furniture and fixtures,	105 19	
for scientific apparatus,	228 36	
for live stock,	901 00	
for traveling expenses,	220 00	
for contingent expenses,	80 65	
for building and repairs,	439 15	
		$15,000 00

Cash on hand July 1, 1897,	$19 73	
Received from State treasurer,	11,200 00	
from fertilizer fees,	3,278 75	
from farm products,	1,763 86	
from miscellaneous sources,	1,663 45	
		$17,925 79
Cash paid for salaries,	$8,901 77	
for labor,	3,167 18	
for publications,	708 27	
for postage and stationery,	236 16	
for freight and express,	154 97	
Amount carried forward,	$13,168 35	

Amount brought forward,	$13,168 35	
Cash paid for heat, light and water,	549 44	
for chemical supplies,	958 54	
for seeds, plants and sundry supplies,	368 02	
for feeding stuffs,	592 46	
for library,	191 10	
for tools, implements and machinery,	34 49	
for furniture and fixtures,	40 23	
for scientific apparatus,	187 11	
for live stock,	313 50	
for traveling expenses,	356 73	
for contingent expenses,	163 96	
for building and repairs,	1,001 86	
		$17,925 79

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1898; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $32,925.79, and the corresponding disbursements $32,925.79. All the proper vouchers are on file, and have been by me examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1898.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 31, 1898.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

During the year, as in previous years, the meteorological division has been principally engaged in the observations of the various weather elements and phenomena, and the compilation of the records in permanent form. The more important results, together with summaries of most of the others, have been published, as heretofore, in bulletin form each month. The usual summary of the weather for the year will be issued when the records are completed.

The records of the division were begun with the year 1889; accordingly, this year completes the first decennial period. A tabulation of the results for the whole period is under way, for use in determining the means of the several weather elements at this station. These results should give normal conditions differing but little from those that may afterward be deduced from observations covering a much longer time, and will be found valuable for the purpose of determining departures from mean conditions in the future. The tables are being arranged in a suitable form for publication, so that they may be issued in bulletin form, if it is thought desirable.

While the self-recording instruments in the tower give generally good results, the records of the sun thermometer are lacking in precision. Cold-air currents and variable wind velocities give at times records which cannot be distinguished from those due to cloudiness. The desirability of having a photographic or an electrical sunshine recorder, for use in conjunction with the Draper instrument, is suggested.

The local forecasts of the weather have been received daily, except Sunday, from the Boston office of the United

States Weather Bureau, and the signals displayed on the top of the tower. At the request of Mr. J. W. Smith, director of the New England section of the United States Weather Bureau, this division has arranged to furnish his office the weekly snow reports, as has been done the past few years. The record of the number of days of sleighing, begun by Professor Metcalf, is being continued.

During the year attempts were made to secure some records of atmospheric electricity by using the quadrant electrometer in the tower, but without success. The extreme sensitiveness of the instrument seems to preclude its working at any such height from the ground, where it is necessarily subjected to the vibrations of the building. Unless a suitable location and mounting can be provided elsewhere, the records it was intended to secure cannot be obtained with any degree of success.

During the year the division purchased one of the resistance boxes made after the design of Prof. Milton Whitney, of the Division of Soils, United States Department of Agriculture, for the purpose of continuing the examination of soil moisture by the electrical method. The electrodes could not be obtained from the manufacturer until early in June, and then a number proved defective. Others were loaned us later by the Department at Washington for continuing the work. The results obtained have been even less satisfactory than those of last year. An examination of the electrodes in the soil showed in some cases short circuits to have been produced by the growth of roots across the face ; in other cases no cause could be found for unusual changes in the resistance. A continuation of the experiment another year may perhaps furnish more satisfactory results, or reveal the causes of some abnormal fluctuations.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The work of this division during the past year has been carried on in about the same lines as for the year of 1897.

Of the experiments conducted, variety testing of fruits, vegetables, flowers, etc., has occupied considerable attention. This work has been undertaken largely in response to the constant calls from the people to know the value of widely advertised new varieties put upon the market with extravagant claims of merit and at exorbitant prices, nine-tenths or perhaps ninety-nine-hundredths of which prove of less value than the old established sorts.

Fruit Investigations.

The Apple.

With each succeeding year the fact is more and more clear that old varieties, from the many conditions of cultivation, from increased injury by insects and fungous pests, grow more feeble and are more and more subject to the continued action of the above agencies; and that new varieties must be found, that can be more easily and cheaply grown, or that will meet the demand for fruit of better quality. The Baldwin apple, for so long a time the most profitable and satisfactory variety for market, has in many places in the last two or three years shown so great a tendency to the dry-rot spots under the skin, long before its normal time for the breaking down of its tissues in the process of ripening, that much of its fruit put on the market has had the effect of decreasing the demand and lowering the price; while the Ben Davis, not nearly as good in quality, but firm, fresh and solid from skin to core, has been sold in our local markets to the exclusion of the home product.

The varieties of apples tested here and in many other sections, that stand out prominently as possessing those qualities that will enable them to successfully compete with the winter varieties shipped to our markets from other States, are the Sutton Beauty, Palmer, MacIntosh Red, Wealthy and Gano.

Sutton Beauty. — Much superior in quality to the Baldwin; is of similar color, perhaps not quite as large unless thinned, and has not shown the dry-rot spots so common in the latter variety. The tree is vigorous and compact in growth, generally with strong, healthy foliage, and so prolific as to require thinning. For local trade it is one of the best.

Palmer. — An apple of medium to large size, of a golden-yellow color when grown on trees in the full exposure of sunlight, but of a green color if grown on closely planted trees. It is of the best quality, tender, crisp and rich. Being an apple of light color and tender flesh, it should be handled very carefully when gathered, and sold in bushel boxes, in which it will not be subjected to much pressure or jolting.

MacIntosh Red. — This is one of the most beautiful of late fall and early winter apples, and, as far as it has been tested in Massachusetts, has done well, and promises to secure much of the trade for fancy apples that demands such varieties as the Fameuse, or Snow apple, which is not successfully grown in this State.

Wealthy. — Generally this variety has proved very satisfactory, but has only been grown on young trees. Its season of ripening is when there is an abundance of fall apples, but it often keeps into early winter. It colors up early, and its beauty, together with its fine quality and somewhat elastic texture, not easily bruised, makes it a good market variety, and should make it valuable as an early shipping apple with which to open the fall trade in European markets, which in the past has been greatly injured by shipping half-ripe and poorly colored Baldwins, and other varieties not as well colored or matured as the latter variety. It has thus far proved prolific, an early bearer and free from disease, but will be greatly improved by thinning.

Ben Davis. — It has been stated on good authority that more of this variety were sold in the Boston markets and on fruit stands during the winter of 1897 than of any other kind, almost the entire amount of which were imported from the western States. In quality and beauty this apple is far below any of the varieties above mentioned; yet its perfect form, uniform size, good keeping qualities, and its very firm, but somewhat elastic flesh, render it less affected by handling and shipping than almost any variety in cultivation. It is very productive, but, as grown in New England, unless thinned, will be of medium or small size. From its behavior thus far it would seem that, if a variety of so poor quality is to be demanded by our markets, it may be grown quite as successfully in many sections of the State as in any other section of the country. This, however, is not necessary; for, if the previously named varieties are well grown, there will be no difficulty in securing the local markets for them, if they are properly sorted and delivered.

Gano. — This variety was introduced as an improved Ben Davis, and, as far as tested, has proved superior to that variety in color, and perhaps to a very slight degree in quality. As yet it has only been produced on young trees, so that its real value cannot be determined without many years' further trial.

Pears.

With the large number of kinds of choice fruit that is now competing with the fruit grown in New England, the pear seems to be less in demand than formerly. Fewer varieties also are found profitable than a few years ago. Of those that stand at the head of the list, the Bartlett, Bosc, Sheldon, Seckle and Hovey are the most generally grown and bring the highest prices.

Peaches.

The interest in peach growing in this State seems on the increase, and the growers are coming to see that it is useless to plant the peach for profit except on high land, where a moderately vigorous growth can be maintained, and

where the temperature is such that the fruit buds mature more fully and are not so liable to be destroyed by extreme cold. The varieties that are popular in the market and that are most profitably and successfully grown are Crawford's Early, Crawford's Late, Old Mixon, Elberta and Crosby. All of these varieties except the Elberta have long been grown in Massachusetts. The latter is an oval peach of large size and of a light-yellow color, with more or less color on the exposed side. It is generally hardy and productive, but the past season, in a great many sections of this and other States, was so seriously injured by the "leaf curl" as to endanger its vitality. Should it continue to be attacked by this disease, it will not long remain a profitable variety.

Plums.

Many growers of this fruit in the State have become discouraged from the lack of profit in the domestic plum, on account of the black knot, plum curculio, leaf blight and brown rot. The results obtained in the station orchards give no reason for such discouragement. Trees of all ages, from thirty years old to those of one or two years' growth, may be found, and almost every variety of any value is represented. Upon these trees will be found hardly a knot to the tree. No leaf blight appeared on the majority of the trees, and many varieties matured their fruit with little or no injury from the brown rot, while a few others were seriously injured. In the average season the use of the Bordeaux mixture, as recommended in the spraying calendar in Bulletin 52, has been found to prevent even the serious injury of the fruit by the brown rot; and the past season, had one or two applications of the copper sulphate solution (one-fourth pound to fifty gallons of water) been made the last of July or in early August, this loss might have been greatly reduced. The black knot has almost wholly succumbed to the treatment outlined in the bulletin mentioned, and the most healthy and vigorous foliage is to be found upon all the trees. The varieties that show the greatest tendency to rot are Lombard, Washington, Gueii, Smith's Orleans and Victoria. Those that show the least are Brad-

shaw, Prince Englebert, Kingston, Grand Duke, Reine Claude and Fellemberg. The amount of rotting of many varieties, however, is largely dependent upon the weather at the time of their approaching maturity, and only prompt and frequent spraying at this time will save the crop.

Of the newer varieties, those that show the most promise are the Kingston, Lincoln and Fellemberg.

Kingston. — Fruit very large, oval in form, slightly pointed at both ends, of the brightest blue color, firm in texture and very acid in quality; ripens late in the season and hangs a considerable time on the tree; very productive and valuable for canning, though it is rather large for this purpose.

Lincoln. — Early, dark purple, of large size and very fine quality; fruited but two years in the station orchards, but it seems very promising.

Fellemberg. — This seems identical with a variety that we have had growing for nearly thirty years under the name of the German prune. It is a regular biennial bearer, but never produces large crops. The fruit is of medium to large size, tapering at both ends. It is of deep purple color, a perfect freestone and of very good quality. Its great value lies in its long keeping and its fine canning qualities.

The Japanese plums, from their rapid growth, great productiveness, early bearing and attractiveness, are being quite largely planted in nearly all sections of the country, and promise to be of considerable value to our fruit growers who do not succeed in growing the domestic varieties. The trees seem to be a little less subject to the black knot and the brown rot, but more subject to the shot-hole fungus, and are often seriously injured by the use of the copper solution and the arsenites. The fruit is attractive, and meets a ready sale; but whether the demand will be large enough to keep up with the increased planting that is going on, time only can determine. All of the varieties of reported value have been planted in the station orchard, forty-eight in all, many of which will fruit next summer for the first time, unless the fruit buds are destroyed by the

cold winter weather. In some cases these varieties are attacked by some disease similar to the peach yellows. Of the varieties that have been tested for several years in various sections of the country, the Abundance, Burbank, Red June and Satsuma have proved satisfactory. Of the newer varieties that are of very fine quality the Wickson, Hale and October Purple may be mentioned.

The Satsuma has not ripened here so as to be of much value for table use, but from the deep-red color of its flesh it is especially valuable for canning. It seems to be weak in self-fertilizing qualities, and needs to be planted among other varieties for the best results in pollination.

Cherries.

The crop of cherries in the station orchard would have been unusually large but for the extremely hot and moist weather at the time of ripening, which caused the fruit to rot badly. The trees had been regularly sprayed with Bordeaux up to the time when it would disfigure the fruit, but there was not a sufficient quantity of the copper from this to spread over the rapidly growing leaves and fruit. From results obtained here and from reports received from other stations, it is probable that spraying thoroughly *immediately* after each rain, as the fruit begins to color, with the copper solution (four ounces of copper sulphate to fifty gallons of water), would largely prevent this loss. It is urged that the coming season those engaged in growing cherries should try this treatment. It must be borne in mind that the application should be made very soon after the rain ceases, as the spores of the brown rot germinate very quickly when placed in moisture, and it is to prevent this germination that the application is made. Heavy rains, especially if soon followed by dry weather, need be little feared, as they tend to wash the spores off the plants, though some may gain a lodgement in the axils of the leaves or in the calyx of the fruit or other places. The varieties most satisfactory were Governor Wood, Napoleon, Black Tartarian and Early Richmond.

Grapes.

Perhaps upon no fruit crop grown in New England is the certainty of protection by spraying so great as with the grape crop, when properly done, and upon which insecticides and fungicides are so easily and cheaply applied. Campbell's Early, the only new variety fruiting that stands out as decidedly promising, produced fruit on several young vines. The growth of vine was satisfactory, the foliage free from disease, the fruit beautiful in appearance and of good quality. The compactness of bunch and firmness of berry will make it a good shipping grape, and, if it does not develop a tendency to disease, it will be a valuable addition to the few varieties that can be profitably grown in New England. It ripens as early or perhaps a little before Moore's Early, and is much superior in quality. The varieties recommended for this section are Winchell or Green Mountain, Worden and Delaware.

Currants.

There is scarcely another fruit the merits of whose new varieties it is so difficult to decide as the currant, because of its great variation in size and productiveness under different conditions. All the new varieties of any prominence have been planted in the station plots, and those that stand out prominently as possessing merit are the Pomona, Wilder and the Red Cross; and, after three years fruiting, their value seems to be in the order given. The Pomona may be mentioned as of especial value, because of its superior quality. We have no records, however, to show that any of the above varieties will be more valuable for general cultivation than Fay's Prolific or the Cherry.

Blackberries.

All of the prominent new varieties have been added to the list under trial, but none have thus far shown themselves to be more valuable than the best older sorts, — the Agawam, Snyder and Taylor's Prolific. On heavy soils, where the growth is large and furnishes an abundant soil

cover, thus keeping the ground cool, the first-named variety proves very satisfactory; but when grown on light land it is of much less value.

The Eldorado continues to do well, and compares favorably with the above-mentioned varieties; but whether it will prove more valuable than any other, can only be determined in large plantation.

Raspberries.

With the red raspberry there has been little or no progress made in improved varieties. The Loudon, which, from its stocky growth, hardiness and fruit of good size, color and quality, seemed very promising, has the past season shown a tendency to mildew of the leaves and young growing canes. If this becomes general, it will greatly reduce its value. The seedlings produced from the seeds of the Shaffer, and referred to in a previous bulletin, have again fruited, and many of them show decided merit, some producing fruit of a bright scarlet color upon plants that propagate only from the tip of the cane, as does the Shaffer; while others produce fruit of the Shaffer type that propagate from suckers, like the common red raspberry.

Strawberries.

The past season was favorable for a large crop of fruit, but the extremely wet weather at the time of ripening caused much loss by rotting. The named varieties were planted in plots of twenty-five plants each, while the most promising of these are planted each season in rows under field culture. Of the varieties in plots (soil medium heavy loam), the Brandywine, Gandy Bell, Glen Mary, Sample and Howard's No. 14 gave the best results. Of those grown under field culture, on light land, the Clyde, Cumberland, Glen Mary, Howard's Nos. 36 and 41 gave the best results.

New Fruits.

Several new species of raspberries, the strawberry-raspberry, Logan-berry, Salmon-berry, May-berry, etc., have been planted, some of which have fruited, but only two seem to possess any merit for this climate. The straw-

berry-raspberry is an herbaceous perennial, the top of which dies to the ground in the winter, but is followed by numerous shoots in the spring from underground stems, that bear most beautiful wine-colored fruit in abundance. This fruit is of a peculiar, insipid, though not unpleasant flavor, and may be the origin of new varieties with a more decidedly pleasant taste. Should such varieties be produced, and a system of cultivation be worked out by which a reasonably certain crop can be secured, it may prove a valuable addition to our list of hardy fruits.

The Logan berry resembles the common dewberry or running blackberry in habit of growth and form of fruit; but the latter is rather larger, and of a dark-red or mahogany color. It possesses a pleasant flavor, but the same obstacle to its general cultivation is met as with the dewberry, — that it is difficult to devise a method of cultivation and training that will give a large crop of fruit every year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. Lindsey.
Assistants, E. B. Holland, F. W. Mossman, B. K. Jones, P. H. Smith, Jr.

Part I. — Laboratory Work.

Outline of Year's Work.

Part II. — Feeding Experiments and Dairy Studies.

Part I.

Extent of Chemical Work.

The laboratory work connected with this department has been much increased during the past year. We have received for examination 159 samples of water, 228 samples of milk, 17 samples of butter, 4 samples of oleomargarine and 81 samples of feed stuffs. The work in connection with this and other divisions of the Station has consisted of the analysis of 394 samples of milk, 26 samples of butter, 292 samples of fodders and 11 miscellaneous samples. In addition to the above, we have collected 754 samples of feed stuffs under the provisions of the feed law, of which 663 samples have been examined. This makes a total of 1,875 substances analyzed, as against 1,147 in 1897. There have also been carried on for the Association of Official Agri-

cultural Chemists, investigations relative to the best methods for the determination of potash, and of the different ingredients in cattle foods, as well as a study of the most desirable methods to be employed in the estimation of sugar. It is hardly possible to express numerically the extent of this work.

CHARACTER OF CHEMICAL WORK.

Water. — We have followed the same general line of investigation as in former years, in the examination of waters sent by farmers and others.

Whenever possible printed instructions are sent for sampling and sending the water. In making a report to the party, a printed form is used. Upon the form there is explained the meaning of the terms used, so that every one will have at least a general idea of what the analytical results are meant to convey.

Those sending the samples have been advised promptly whether in our judgment the water was suitable for drinking and general domestic purposes. Whenever necessary, suggestions have been offered with the hope of improving the family supply. We again caution everyone who depends upon wells and springs for their drinking water to have all sink drains, etc., remote from the well, and to keep the ground in the vicinity free from objectionable matter. Lead pipes should never be used in drawing water from wells.

Milk. — Some of the milk sent to the station has been from farmers who ship their milk to the Boston market, and having been notified by the contractors that their article was below the legal standard, wished to ascertain if such was the fact, and if so, what could be done for its improvement. To such we have given the same advice as appeared in our last annual report, to which interested parties are referred.

Many farmers are now sending occasional samples of milk, cream and skim-milk to the station, to ascertain the amount of butter fat contained in them. These producers sell their milk to creameries, and they are desirous of knowing its quality for butter production. This is a

very encouraging sign, for it shows that the farmer really wishes to know the butter-producing capacity of his cows, and the efficiency of his separator, or Cooley creamer, in removing the fat from his milk. To all who desire, printed information is given, stating how to ascertain the yearly butter capacity of dairy cows.

Much of the milk and butter analyzed in connection with our own experiments has been studied with a great deal of care. We have estimated the water, solids, fat, casein, milk sugar, and ash in a large number of samples. We have also made a very thorough examination of 26 samples of butter fat produced by cows employed in connection with our feeding experiments. There have been determined in duplicates or triplicates, volatile acids, specific gravity, melting point, and the iodine number.

Cattle Feeds. — Our feed law has now been in operation about one and one-half years. We have made frequent inspections covering the entire State, and have published two especially prepared bulletins giving the results of our investigations. We have endeavored to make these bulletins as practical as possible, and judging from the way in which the bulletins are received, it is believed that we have in a measure succeeded. During the spring of 1898 a considerable quantity of adulterated cotton-seed meal was found in various sections of the State. Printed slips of warning were immediately sent to 100 newspapers in the State, and a concise circular was also mailed to every grain dealer, cautioning against its purchase. While meal of this character generally has a darker appearance than the prime article, samples of inferior meal have recently been found having quite a bright yellow color. A number of reputable manufacturers now print a guaranty upon every package, and purchasers are strongly advised to buy only the guaranteed article. The effect of the feed law has been to call the attention of all manufacturers to the necessity of branding their products, and having them run as even as possible in composition. Many of the more reputable manufacturers are now placing a guaranty upon their feeds, and it is hoped others will soon follow.

Many new feeds are constantly being offered for sale in our markets. A number have appeared during the year 1898. Our object is to secure samples of these materials promptly, and ascertain their feeding and comparative commercial values. For detailed information the reader is referred to Bulletins 53 and 56.

Other Chemical Work. — The analyses of feed stuffs and manures in connection with the numerous digestion experiments carried on by this division, involves a considerable amount of time and effort, but because of this work we are enabled to state with a reasonable degree of accuracy the feeding and commercial values of the concentrated feeds sold upon the market, and of the coarse feeds produced upon our farms.

It is the object of this division to assist the Association of Official Agricultural Chemists as much as possible in perfecting methods of chemical analyses, and in finding out methods for the estimation of the quantity and nutritive value of several of the newer carbohydrates. We spend whatever time can be had during each year in working along these lines, believing it will be productive of much good in the future. During the past year we have given attention to the estimation of pentosans, starch and sugar in agricultural plants.

The chemical work received from the agricultural division has very much increased during the past year. This work consists of the determination of dry matter in a large number of plants, the estimation of starch in potatoes, the analyses of feed stuffs used in poultry experiments, and in general fodder analyses. This increased work is now severely taxing the resources of our chemical force.

Part II.

A. Cleveland Flax Meal v. Old-process Linseed Meal for Early Lambs.

Object of the Experiment.

It has recently been claimed, by parties who grow early lambs for market, that the so-called new-process linseed meal (Cleveland flax meal) exerted an injurious effect upon the young lamb. Some claim that this meal did not favor growth, and others that it was the cause of frequent sudden deaths. On the other hand, it was stated that the old-process meal did not have these injurious effects, but favored rapid growth and fattening. The station was asked to throw some light on the subject, and conducted the following experiment in the winter and early spring of 1898.

The Experiment.

Six grade Southdown ewes were brought to the station barn the first week in February, and each placed in a separate pen six feet wide by fifteen feet long. The pens were separated by stout wire netting, thus enabling the animals to see each other. The ewes were all in fair condition, and in about two weeks' time began to drop their lambs. Each lamb was weighed five days after being dropped.

Daily Feed for the Ewes after Lambing. — Two pounds corn ensilage, rowen *ad libitum*, 1 pound grain mixture. The grain mixture* was gradually increased until each ewe received 2½ pounds daily. This grain feed was kept up as long as the ewes would take it, and was then gradually reduced. The grain mixture, as will be noticed, contained about one-third of one of the two kinds of linseed meal.

Daily Feed for the Lambs. — The pens were so arranged that the lambs gained access to a separate compartment, containing a mixture of grains. They soon learned to go in as soon as the feed was placed in the troughs. It was our aim

* The grain mixture consisted of 7.5 pounds of old-process linseed or flax meal, 7.5 pounds of bran, 5 pounds corn meal and 5 pounds gluten feed.

to feed them what they would eat daily: grain mixture No. 1, 7.5 pounds flax meal or old-process linseed meal, 7.5 pounds bran, 10 pounds corn meal.

After feeding this mixture for about two weeks, a second was fed, as follows: 10 pounds flax meal or old-process linseed meal, 5 pounds bran, 5 pounds corn meal.

When the lambs each reached 40 pounds in weight, the mixture was again changed to: one-third flax meal or old-process linseed meal, one-third bran, one-third corn meal.

It was our object to give the lambs as much of each of the two linseed meals as they would stand, and keep in a healthy, growing condition.

Care of the Lambs. — The lambs were kept in the pens with the ewes. As the season advanced, they were allowed the run of a large yard in the warmer part of sunny days.

Record of Growth.

Flax Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 8, . .	March 3,	May 5,	62	15.25	67.00	51.75	.83
Lamb No. 6, . .	March 1,	May 18,	78	10.25	57.50	47.25	.62
Lamb No. 7, . .	March 1,	May 25,	85	10.50	53.00	42.50	.50
Lamb No. 1, . .	February 25,	May 18,	82	9.50	47.50	38.00	.46
Lamb No. 2, . .	February 25,	May 25,	89	9.25	41.00	31.75	.36
Average, . .	-	-	79	10.95	53.20	42.25	.54

Old-process Linseed Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 5, . .	February 25,	April 29,	63	11.75	52.25	40.50	.64
Lamb No. 3, . .	February 25,	May 18,	82	11.00	50.00	39.00	.48
Lamb No. 4, . .	February 25,	May 25,	89	8.75	44.50	35.75	.40
Lamb No. 9, . .	March 19,	June 1,	74	10.25	52.25	42.00	.57
Lamb No. 10, . .	March 19,	June 1,	74	9.00	51.00	42.00	.57
Average, . .	-	-	76	10.15	50.00	39.85	.53

Note. — Lambs 6 and 7, 1 and 2, 3 and 4, 9 and 10, were twins.

The lambs were shipped to Ira C. Lowe of Greenfield, Mass., who slaughtered them, and reported on their condition. He had no knowledge as to which lambs were fed the flax meal and which lambs were fed the old-process linseed meal ration. Lamb No. 8 was reported to be of extra quaility, Lamb No. 5 next in quality to No. 8, and the others of fair quality only. Looking at the average figures in the above tables, it will be seen that each lot of five lambs showed the *same daily gain*. Mr. Lowe noticed no particular advantage in favor of either lot.

Results of the Experiment.

As a result of our observations, we conclude: —

That the flax meal had no injurious effect either upon the growth or dressed appearance of the lambs, and that both sets of lambs produced the same average daily growth, and were both in the same average condition when slaughtered.

Remarks and Suggestions.

It is well known to all growers of early lambs, that in order to secure a rapid growth of the lamb, the ewe should be thrifty, and a good milker. A liberal feeding will aid in keeping up a continuous flow of milk. The early growth of the lamb will depend very much on the constitution it inherits, and upon its success in obtaining a large supply of milk. Easily digested nitrogenous feed stuffs will unquestionably assist in producing quick growth, but they are secondary to the milk supply. This is quite forcibly illustrated in case of our experiments as described above. Lamb No. 8 was single, and its mother was an excellent milker. The lamb was above the average in size and vigor when dropped. He grew rapidly, showing .83 of a pound gain per day. It was noticed that this lamb did not consume very large amounts of grain, although he had a constant opportunity. He derived the larger part of the food necessary for his growth from his mother. Lamb No. 5 was also a single lamb. He made a very good growth, but the ewe was not as good a milker as the previous one. This lamb took more grain than did No. 8, but was not able to make as

rapid growth. The other lambs were twins. They did not grow as rapidly as did the single lambs, because of the lack of milk, although they ate quite freely of the grain mixtures. Lambs Nos. 6 and 7 came from a good milker, and they were also quite vigorous and hearty eaters.

In addition to inherited constitution and plenty of milk, it is very essential, in order to secure rapidity of growth, that early lambs should be housed in a warm, dry barn, and have a maximum amount of sunlight from a southern exposure.

B. Corn Meal *v.* Hominy Meal, and Corn Meal *v.* Cerealine Feed for Growing Pigs.

Experiment I. — Corn meal *v.* hominy meal.
Experiment II. — Corn meal *v.* cerealine feed.
Experiment III. — Corn meal *v.* cerealine feed.

Objects of the Experiments.

Skim-milk is a very valuable feed for growing pigs. It is a digestible, nitrogenous feed stuff. Of itself it is not a complete food, being deficient in solid matter as well as in carbohydrates (starchy material). In order to make a complete food, carbohydrate feeds are necessary to properly balance the daily ration. A combination of skim-milk and corn meal (1 quart milk and from 3 to 6 ounces of meal) has been found to make a most excellent feed for rapid growth. The object of the above-mentioned experiments was to get at the feeding values of hominy meal and cerealine feed, when compared with corn meal, for this purpose.

What Hominy Meal is. — Hominy meal consists of the hulls, germ and some of the starch and gluten of the corn, ground together. This separation is said to be brought about solely by the aid of machinery. The hard, flinty part of the corn is the hominy, which is used as a human food.

What Cerealine Feed is. — This feed consists also of the hull and a portion of the starch of the corn. It contains rather less of the starch than does the hominy meal. It is

the by-product resulting from the preparation of the breakfast preparation known as cerealine flakes. It is very coarse looking, and appears much like unground corn hulls.

Results of Experiments.

1. Hominy meal produced 5 to 7 per cent. more growth, when fed to pigs in connection with skim-milk, than did corn meal. This difference was probably due to the dryer condition of the hominy meal, and nearly disappears when the meals are compared on a basis of dry matter they contained.

2. In view of the fact that Pig IV. was thrown out of the experiment, we should hesitate to say that the hominy meal had proved itself in any degree superior to the corn meal. This experiment would seem to indicate, however, that pound for pound, as found in the market, the hominy meal is at least fully as valuable as the corn meal.

3. In the two experiments with cerealine feed and corn meal, the corn meal produced 5 per cent. more growth than did the cerealine feed. Corn meal constituted but 62 per cent. of the dry matter of the ration; and, if 62 per cent. of dry matter of the ration in the form of corn meal produced a gain of 5 per cent., 100 per cent. of corn meal — *e. g.*, its full effect — would show an 8 per cent. gain.

4. We think we are justified in saying that corn meal is from 5 to possibly 10 per cent. more valuable than cerealine feed for use in connection with skim-milk for growing pigs.

5. Cerealine feed might prove equal to corn meal as a feed for milch cows, as digestion experiments with sheep have shown it to contain as much digestible matter as corn meal. It is very probable that pigs are not able to digest the hulls of the corn as well as other animals.

6. Because of the important part played by the individuality of the animal, we are frank to confess that a larger number of pigs would be desirable in conducting experiments of this kind. We feel confident, however, that these experiments give a fairly accurate representation of the comparative values of the several feed stuffs.

Experiment I. — Corn Meal v. Hominy Meal.

Nov. 23, 1896, to March 1, 1897 (98 Days). — Eight grade Chester White pigs, all of the same litter, were purchased in October. They were first fed skim-milk alone, and finally divided into two lots, and corn or hominy meal added to the skim-milk diet. Pigs Nos. I. and II. were together in one pen, and so were pigs Nos. VII. and VIII.; the others were in separate pens. Pig IV. was taken sick during the experiment, and his record is not considered. Each pig was allowed from 7 to 10 quarts of skim-milk daily, and from 3 to 6 ounces of grain for each quart of milk, the quantity depending on the appetite and stage of growth of the animals. As the pigs advanced in age and growth, the quantity of grain was increased, thus furnishing an increased food supply and an increasing amount of carbohydrates.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. V., ...	884.00	1,927.12	183.08	255.44	223.25
Pig No. VI., ...	883.00	1,924.94	182.87	255.44	223.25
Pigs Nos. VII. and VIII., .	1,766.00	3,849.88	365.74	510.88	446.50
Totals, ...	3,533.00	7,701.94	731.69	1,021.76	893.00
Averages, . . .	883.25	1,925.48	182.92	255.44	223.25

Hominy Meal Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Hominy Meal (Pounds).	Dry Matter (Pounds).
Pigs Nos. I. and II., . .	1,768.00	3,854.24	366.15	255.06	470.23
Pig No. III., . . .	883.00	1,924.94	182.87	255.44	235.46
Totals, ...	2,651.00	5,779.18	549.02	765.56	705.69
Averages, . . .	883.67	1,926.39	183.01	255.19	235.23

The above tables show that each lot of pigs consumed identical amounts of skim-milk, and very nearly equal amounts of grain. The hominy meal lot ate about 12 pounds more of dry grain per pig, than did the corn meal lot.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. V., ...	54.50	184.25	129.75	1.32
Pig No. VI., ...	58.25	167.00	130.25	1.33
Pigs Nos. VII. and VIII., . .	109.25	188.50 185.25	243.00	2.48
Totals, ...	222.00	725.00	503.00	5.13
Averages, ...	55.50	181.25	125.75	1.28

Hominy Meal Lot.

Pigs Nos. I. and II., . . .	115.50	387.25	271.75	2.77
Pig No. III., ...	57.75	196.00	138.25	1.41
Totals, ...	173.25	583.25	410.00	4.18
Averages, ...	57.75	194.42	136.66	1.39

One notes a very slight difference in favor of the hominy fed lot, this being caused perhaps by the slightly increased amount of actual dry matter found in the hominy meal.

By referring to the table, it will be noticed that each pig received 223.25 pounds of perfectly dry corn meal and 235.23 pounds of perfectly dry hominy meal.

Total Gain in Dressed Weight.

Corn Meal Lot.

Number of Pig.	Dressed Weight at End of Experiment (Pounds).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Total Gain in Dressed Weight (Pounds).	Loss in Weight in Dressing (Pounds).
Pig No. V., . . .	150.50	44.52	105.98	18.31
Pig No. VI., . . .	154.25	47.67	106.58	18.17
Pigs Nos. VII. and VIII.,	287.25	89.09	198.16	18.45
Totals, ...	592.00	181.28	410.72	54.83
Averages, . . .	148.00	45.32	102.68	18.28

Hominy Meal Lot.

Pigs Nos. I. and II., . .	306.00	91.25	214.75	20.89
Pig No. III., . . .	152.00	44.79	107.21	22.45
Totals, ...	458.00	136.04	321.96	43.34
Averages, . . .	152.66	45.35	107.32	21.67

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. V., ...	3.13	3.84
Pig No. VI., ...	3.12	3.81
Pigs Nos. VII. and VIII., ...	3.34	4.09
Averages, ...	3.20	3.91

Hominy Meal Lot.

Pigs Nos. I. and II., ...	3.08	3.89
Pig No. III., ...	3.03	3.90
Averages, ...	3.06	3.89

The very slight difference between the gains in the two lots is within the limit of error.

Experiment II. — Corn Meal v. Cerealine Feed.

April 12 to July 26, 1897 (106 Days). — The six pigs used in this experiment were grade Chester Whites, about five weeks old when purchased, March 2. They were brought into separate pens April 1, and the experiment began April 12. Each pig was fed 6 to 9 quarts of skim-milk daily, together with 3 ounces of grain for each quart of milk. The amount of grain was gradually increased as the animal demanded it, until some 4 pounds daily were fed. The milk never exceeded 9 quarts per day.

At the beginning of the experiment the animals were receiving 1 part protein to 3 parts carbohydrates. The ration was gradually widened, until towards the close of the experiment the nutritive ratio was as 1 to 7. The corn meal heated during the latter part of the experiment, and became somewhat musty.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. I., ...	738.00	1,608.84	152.84	243.63	204.98
Pig No. II., ...	738.00	1,608.84	152.84	243.63	204.98
Pig No. III., ...	738.00	1,608.84	152.84	243.63	204.98
Totals, ...	2,214.00	4,826.52	458.52	730.89	614.94
Averages, . . .	738.00	1,608.84	152.84	243.63	204.98

Cerealine Feed Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. IV., ...	738.00	1,608.84	152.84	243.63	214.39
Pig No. V., ...	738.00	1,608.84	152.84	243.63	214.39
Pig No. VI., ...	738.00	1,608.84	152.84	243.63	214.39
Totals, ...	2,214.00	4,826.52	458.52	730.89	643.17
Averages, . . .	738.00	1,608.84	152.84	243.63	214.39

Some 10 pounds more dry cerealine feed were consumed per pig than corn meal during the experiment, due to the dryer condition of the cerealine feed when fed.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I.,	51.25	188.00	136.74	1.29
Pig No. II.,	48.50	184.00	135.50	1.28
Pig No. III.,	43.25	184.25	141.00	1.33
Totals,	143.00	556.25	413.25	3.90
Averages,	47.67	185.42	137.75	1.30

Cerealine Feed Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV.,	44.00	175.50	131.50	1.24
Pig No. V.,	41.00	170.50	129.50	1.22
Pig No. VI.,	49.25	186.00	136.75	1.29
Totals,	134.25	532.00	397.75	3.75
Averages,	44.75	177.33	132.58	1.25

A slight gain in favor of the corn meal lot is noted.

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I.,	2.62	3.28
Pig No. II.,	2.64	3.30
Pig No. III.,	2.54	3.17
Averages,	2.60	3.25

Cerealine Feed Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV.,	2.79	3.49
Pig No. V.,	2.84	3.54
Pig No. VI.,	2.69	3.37
Averages,	2.77	3.46

The above figures show a slight difference in favor of the corn meal, rather less dry matter in corn meal being required to make a pound of growth than in cerealine feed.

Experiment III. — Corn Meal v. Cerealine Feed.

Oct. 25 to Jan. 10, 1898 (78 Days). — The six pigs employed in this experiment were a cross between the Poland-China and the Chester White. They were received early in September, when five weeks old, and allowed the run of a large pen out of doors until October 20, when they were placed in separate pens in the feeding barn, and divided as equally as possible into two lots. They were in a very vigorous condition. In this experiment the cerealine feed heated towards the close of the experiment. It was shovelled over and dried at once when this condition was observed, and the experiment continued. The pigs ate it with seeming relish at all times.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. IV.,	468.00	1,020.24	96.92	226.50	197.06
Pig No. V.,	468.00	1,020.24	96.92	226.50	197.06
Pig No. VI.,	468.00	1,020.24	96.92	226.50	197.06
Totals,	1,404.00	3,060.72	290.76	679.50	591.18
Averages,	468.00	1,020.24	96.92	226.50	197.06

Cerealine Feed Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. I.,	468.00	1,020.24	96.92	226.50	201.59
Pig No. II.,	468.00	1,020.24	96.92	222.50	198.03
Pig No. III.,	468.00	1,020.24	96.92	226.50	201.59
Averages,	468.00	1,020.24	96.92	225.20	200.40

The amount of feed consumed by the two lots is practically identical.

TOTAL GAIN IN LIVE WEIGHT.

Corn Meal Lot.

NUMBER OF PIG.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV.,	68.50	172.50	104.00	1.33
Pig No. V.,	67.75	172.00	104.25	1.34
Pig No. VI.,	66.75	173.00	106.25	1.36
Totals,	203.00	517.50	314.50	4.03
Averages,	67.67	172.50	104.83	1.34

Cerealine Feed Lot.

NUMBER OF PIG.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I.,	73.75	169.00	95.25	1.22
Pig No. II.,	57.25	150.00	92.75	1.19
Pig No. III.,	68.75	174.00	105.25	1.35
Totals,	199.75	593.00	293.25	3.76
Averages,	66.58	164.33	97.75	1.25

Each pig in the corn meal lot shows an average gain of 7 pounds over the cerealine feed pigs. This might partly be accounted for by reason of the poor condition of the cerealine feed, already mentioned.

DRY MATTER REQUIRED TO PRODUCE ONE POUND LIVE AND DRESSED WEIGHT.

Corn Meal Lot.

NUMBER OF PIG.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV.,	2.83	3.53
Pig No. V.,	2.82	3.52
Pig No. VI.,	2.77	3.42
Averages,	2.81	3.49

Cerealine Feed Lot.

NUMBER OF PIG.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I.,	3.13	3.91
Pig No. II.,	3.18	3.98
Pig No. III.,	2.84	3.55
Averages,	3.05	3.81

The dry matter required to produce a pound of gain confirms the results given in the tables under gain in live weight, and shows that in this experiment a pound of live weight was produced by $\frac{1}{4}$ of a pound less of absolutely dry corn meal than of dry cerealine feed. The conclusions from these three experiments have already been given on page 28.

Composition of Feeds (used in Three Feeding Experiments).

Separate Ingredients of Feeds.	Average Skim-milk, All Experiments (per Cent.).	Experiment I.		Experiment II.			Experiment III.	
		Corn Meal (per Cent.).	Hominy Meal (per Cent.).	Corn Meal, I. (per Cent.).	Corn Meal, II. (per Cent.).	Cerealine Feed (per Cent.).	Corn Meal (per Cent.).	Cerealine Feed (per Cent.).
Water, . .	90.50	12.63	7.82	20.00	14.00	12.00	13.00	11.00
Protein, . .	-	8.78	10.59	8.86	9.03	9.55	9.64	10.96
Fat, . . .	-	4.08	8.50	2.18	2.15	6.60	3.59	6.30
Extract matter, .	-	71.73	65.46	65.80	71.68	65.23	70.80	64.55
Fibre, . . .	-	1.42	4.11	1.82	1.81	4.40	1.70	4.36
Ash, . . .	-	1.36	3.52	1.34	1.33	2.22	1.27	2.83
Totals, . .	-	100.00	100.00	100.00	100.00	100.00	100.00	100.00

C. The Cost of Pork Production.

In a section of our State the cream from the milk produced upon the farm is sold to the creamery, and the skim-milk is either fed to pigs or calves. A large number of experiments have been made at this station with growing pigs. The pigs averaged from 37 pounds in weight at the beginning of the experiments to 183 pounds when slaughtered. The daily rations have been essentially as follows: —

I. From 5 to 7 quarts of milk per day; and, beginning with 3 ounces of corn meal to each quart of milk, the grain has been gradually increased to satisfy the appetite of the animal.

II. About the same quantity of milk, and, instead of the corn meal, other carbohydrate foods, such as ground rye, wheat, hominy meal, cerealine feed and oat feed, to satisfy appetites.

III. About the same quantity of milk, together with 3 to 6 ounces of corn meal to each quart of milk, and a

mixture of one-third wheat bran, one-third gluten meal and one-third corn meal, to satisfy appetites.

More exact statements of rations will be found farther on. We rarely had more than from 5 to 7 quarts of milk daily for each pig. The animals did well with this amount of milk; if they did not secure this quantity, their growth was noticeably slower.

Explanation of Tables.

As a result of these various experiments, we have endeavored to ascertain: —

1. The price that skim-milk has returned per quart.

2. The cost of feed required to produce *a pound* of *live* or *dressed weight*, taking the various grains at a reasonable range of market prices, and allowing either ¼ or ½ cent per quart for the milk.

In tables I., II. and III. will be found the results where milk and corn meal have been fed.

Tables IV., V. and VI. will show the results where milk and other starchy (carbohydrate) feeds have been substituted for the corn meal, such as hominy or cerealine feeds, rye and wheat meals ("grain").

Tables VII., VIII. and IX. show the results where milk and corn meal were fed, and, in addition, wheat bran, gluten meal, etc. ("other grains").

Tables X. and XI. show the average of all the preceding, being the results with 140 pigs, weighing 37 pounds at the beginning, and 183 pounds at the close of the experiments.

TABLE I. — *Milk and Corn Meal.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 21 pigs,	16,421	35,797.78
Total corn meal consumed by 21 pigs,	-	5,531.10
Live weight, actually gained,	-	3,012.25
Dressed weight, calculated,	-	2,409.80

TABLE II. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH CORN MEAL AT $15 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.48	.63	.77	.44	.58	.73	.39	.54	.69
Per 100 pounds (cents),	22.02	28.90	35.37	20.19	26.61	33.48	17.89	24.77	31.19

TABLE III. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 per ton, and milk at ¼ cent per quart,	2.74	3.44
With corn meal at $15 per ton, and milk at ½ cent per quart,	4.11	5.13
With corn meal at $17.50 per ton, and milk at ¼ cent per quart,	2.98	3.72
With corn meal at $17.50 per ton, and milk at ½ cent per quart,	4.33	5.41
With corn meal at $20 per ton, and milk at ¼ cent per quart,	3.21	4.02
With corn meal at $20 per ton, and milk at ½ cent per quart,	4.59	5.71

TABLE IV. — *Milk and Different Starchy Feeds.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 22 pigs, ...	13,153	28,630
Total "grain" consumed by 22 pigs, ...	-	5,135
Live weight, actually gained, ...	-	2,597
Dressed weight, calculated, ...	-	2,078

TABLE V. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH "GRAIN" AT $15 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound)
Per quart (cents),	.50	.65	.81	.45	.60	.76	.40	.56	.87
Per 100 pounds (cents),	22.90	30.10	37.10	20.60	27.80	35.10	18.35	25.69	39.91

TABLE VI. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With "grain" at $15 per ton, and skim-milk at ¼ cent per quart,	2.75	3.43
With "grain" at $15 per ton, and skim-milk at ½ cent per quart,	4.01	5.01
With "grain" at $17.50 per ton, and skim-milk at ¼ cent per quart,	3.00	3.75
With "grain" at $17.50 per ton, and skim-milk at ½ cent per quart,	4.26	5.32
With "grain" at $20 per ton, and skim-milk at ¼ cent per quart,	3.24	4.05
With "grain" at $20 per ton, and skim-milk at ½ cent per quart,	4.51	5.63

TABLE VII. — *Milk, Corn Meal, Bran, Gluten Meal, etc.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 97 pigs,	62,319	135,855
Total corn meal consumed by 97 pigs,	-	21,602
Total "other grains" consumed by 97 pigs,	-	12,663
Live weight actually gained,	-	15,080
Dressed weight calculated,	-	12,064

TABLE VIII. — *Price obtained for Skim-milk.*

Price obtained for Skim-milk.	With Corn Meal at $15 per Ton, "Other Grains" at $17.50 per Ton, and Dressed Pork at —			With Corn Meal at $17.50 per Ton, "Other Grains" at $20 per Ton, and Dressed Pork at —			With Corn Meal at $20 per Ton, "Other Grains" at $22.50 per Ton, and Dressed Pork at —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents),	.53	.72	.92	.45	.65	.85	.39	.59	.78
Per 100 pounds (cents),	24.30	33.20	42.10	21.20	30.00	39.00	18.00	27.00	36.00

TABLE IX. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 "other grains" at $17.50 and milk at ¼ cent per quart,	2.84	3.55
With corn meal at $15 "other grains" at $17.50 and milk at ½ cent per quart,	3.87	4.84
With corn meal at $17.50 "other grains" at $20 and milk at ¼ cent per quart,	3.13	3.90
With corn meal at $17.50 "other grains" at $20 and milk at ½ cent per quart,	4.16	5.20
With corn meal at $20 "other grains" at $22.50 and milk at ¼ cent per quart,	3.41	4.26
With corn meal at $20 "other grains" at $22.50 and milk at ½ cent per quart,	4.44	5.55

TABLE X. — *Price obtained for Skim-milk (All Experiments).*

Average Price obtained for Skim-milk.	With Corn Meal and Other Starchy Foods at $15 per Ton, "Other Grains" at $17.50 per Ton, and Dressed Pork at —			With Corn Meal and Other Starchy Foods at $17.50 per Ton, "Other Grains" at $20 per Ton, and Dressed Pork at —			With Corn Meal and Other Starchy Foods at $20 per Ton, "Other Grains" at $22.50 per Ton, and Dressed Pork at —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents),	.50	.67	.83	.45	.61	.78	.39	.56	.78
Per 100 pounds (cents),	23.07	30.73	38.19	20.66	28.14	35.86	18.08	25.82	35.70

TABLE XI. — *Average Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 "other grains" at $17.50, milk at ¼ cent per quart,	2.78	3.47
With corn meal at $15 "other grains" at $17.50, milk at ½ cent per quart,	4.00	4.99
With corn meal at $17.50 "other grains" at $20, milk at ¼ cent per quart,	3.04	3.79
With corn meal at $17.50 "other grains" at $20, milk at ½ cent per quart,	4.25	5.31
With corn meal at $20 "other grains" at $22 50, milk at ¼ cent per quart,	3.63	4.53
With corn meal at $20 "other grains" at $22.50, milk at ½ cent per quart,	4.51	5.63

D. RATIONS FOR GROWING PIGS.

RATION No. I. — *With Unlimited Supply of Milk.*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	3 ounces of corn meal * to each quart of milk.
60 to 100 pounds,	6 ounces of corn meal to each quart of milk.
100 to 180 pounds,	8 ounces of corn meal to each quart of milk.

RATION No. II. — *With Limited Supply of Milk (5 to 6 quarts per Pig daily).*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	3 ounces of corn meal * to each quart of milk, and then gradually increase corn meal to satisfy appetites.
60 to 100 pounds,	
100 to 180 pounds,	

* Wheat, rye or hominy meals can be substituted for corn meal.

RATION No. III.

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	Milk at disposal, plus mixture of one-third corn meal, one-third wheat bran and one-third gluten meal, to satisfy appetites.
60 to 100 pounds,	Milk at disposal, plus mixture of one-half corn meal, one-quarter wheat bran and one-quarter gluten meal, to satisfy appetites.
100 to 180 pounds,	Milk at disposal, plus mixture of two-thirds corn meal, one-sixth wheat bran and one-sixth gluten meal, to satisfy appetites.

RATION No. IV.*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds, .	3 ounces of corn meal to each quart of milk, and 4 ounces of gluten feed as a substitute for quart of milk.
60 to 100 pounds, .	Milk at disposal, and mixture of one-half corn meal and one-half gluten feed, to satisfy appetites.
100 to 180 pounds, .	Milk at disposal, and mixture of two-thirds corn meal and one-third gluten feed, to satisfy appetites.

* This ration is preferable to Ration No. II.

E. EXPERIMENTS WITH SALT HAY.

The extensive series of experiments carried on to ascertain the nutritive value of different kinds of salt hay were completed and the experiments and results published in Bulletin No. 50, in January, 1898, to which the reader is referred for all details.

F. EXPERIMENTS TO ASCERTAIN THE EFFECT OF DIFFERENT AMOUNTS OF PROTEIN UPON THE COST AND QUALITY OF MILK.

During the winter of 1897–98 two experiments, with twelve cows, were carried out, to investigate the effect of 1.50, 2 and 2.50 pounds of protein upon the cost and quality of milk. The total amount of digestible nutrients fed daily was the same in each case. Experiment I. extended over nine weeks and Experiment II. over four weeks. This work has not been published. About 5 per cent. more milk was produced on 2 pounds, and 10 per cent. more on 2½ pounds, of protein daily, than when the animals received 1[1] pounds each. The quality of the milk was scarcely changed. The cost of the different rations will depend upon the cost of the several concentrated feeds. As the market has been for the past two years, milk produced by aid of the rations containing 2½ pounds of protein daily would cost rather less than that produced by 1½ or 2 pounds. The manure derived from the highest protein ration would be 10 per cent. more valuable, and the animals generally have a better appearance than when receiving but 1½ pounds per day. It is believed that a continuous feeding of 2 or 2½ pounds of protein daily tends, to some extent, to develop the milk-producing capacity of the cow. Animals that will

not stand a reasonably generous feeding had better be consigned to the butcher. The writer is of the opinion that animals weighing from 800 to 1,000 pounds, producing from 10 to 15 quarts of milk per day, should receive about 2.5 pounds of digestible protein and 15 to 16 pounds of total nutrients daily. This is in accordance with Wolff's rations. When protein is costly, it might be advisable to reduce the amount to 2 pounds daily. The detailed records of these and other experiments along this line will be published later.

G. Digestion Experiments.

During the past three years there have been made about forty successful digestion experiments, mostly with the various concentrated feeds, to ascertain their value for feeding purposes. The details of the experiments have not been published. Some of the results (digestion coefficients) have been published in Bulletin No. 50, and in the annual reports for 1896 (page 135) and 1897 (page 84); others follow below. The results have been utilized in showing the nutritive value of a number of coarse fodders, and in preparing a key to the comparative values of concentrated feeds, as given in Bulletin No. 56 (page 23). It is hoped to publish the details of the experiments before long.

Digestion Coefficients resulting from Digestion Experiments.

Kind of Feed Stuff.	Number of Different Samples.	Number of Single Trials.	Dry Matter (per Cent.).	Protein (per Cent.).	Fat (per Cent.).	Extract (per Cent.).	Fibre (per Cent.).	Ash (per Cent.).
Hay (largely *Poa pratensis*),	1	6	62	61	50	63	65	46
Hay (largely *Poa pratensis*),	1	4	60	58	53	61	60	50
Average, both samples,	2	10	61	60	51	62	63	48
Hay of mixed grasses (late cut),	1	2	53	54	39	54	56	26
Hay of mixed grasses (late cut),	1	2	57	55	44	57	59	42
Barn-yard millet hay (late blossom),	1	3	57	64	46	52	62	63
Barn-yard millet (green, blossom),	1	2	74	68	64	76	74	66
Barn-yard millet (green, week later than above),	1	1	67	72	61	65	71	61
Peas and oats (green, in blossom),	1	3	70	70	57	76	68	49
Vetch and oats (green, in blossom),	1	3	67	75	47	68	68	53
Corn ensilage (Pride of the North),	1	2	74	45	77	82	80	26
Hominy meal,	1	1	89	53	94	94	–	–
Cerealine feed,	1	3	90	80	81	95	82	–
Peoria gluten feed,	1	3	91	85	88	95	–	–
Quaker oat feed,	1	3	62	81	89	67	43	–
Victor corn and oat feed,	1	3	75	71	87	83	48	–
H. O. dairy feed,	1	2	65	78	85	70	41	–
H. O. horse feed,	1	1	70	74	84	79	35	–

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

Soil Tests.

During the past season four soil tests upon the co-operative plan agreed upon in Washington in 1889 have been carried out. Two of these were upon our own grounds, — one with corn and the other with onions as the crop; one in Norwell, Plymouth County, with oats; and one in Montague, Franklin County, also with oats.

1. Soil Test with Corn. Amherst.

The past is the tenth season that the experiment on this field has been in progress. The crops in order of rotation have been corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch crop, rye, soy beans, white mustard, and this year corn once more. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer; three have received but a single important manurial element, — every year the same; three have received each year two important elements; one has received all three yearly; and one each has received yearly lime, plaster and farm-yard manure. It will be seen that the greater part of the field has remained either entirely unmanured or has had but a partial manuring, and it will be readily understood that the degree of exhaustion of most of the plots is considerable. The nothing plots produce this year an average of about twelve bushels of shelled corn per acre; and even this figure is somewhat too high, owing to the fact that after this long period one of the nothing plots which adjoins the plot which has been yearly manured at the rate of five cords per acre

begins to feel the effect of the high fertility of its neighbor, although separated from it by a strip three and one-half feet wide.

The single-element plots, one receiving nitrate of soda only yearly, another phosphoric acid and the third potash, give this year practically equal crops of grain, respectively at the rate of 20.6, 18.5 and 19.8 bushels per acre. The nitrate of soda and dissolved bone-black give a crop at the rate of 32 bushels per acre, while nitrate of soda and potash give at the rate of but 10.9 bushels. The dissolved bone-black and muriate of potash do much better, yielding at the rate of 41.2 bushels. The fertilizer supplying nitrogen, phosphoric acid and potash gives a crop of 55.9 bushels, while manure gives 67.7 bushels.

It may be remembered that in each of the three previous years in which this field has produced corn the muriate of potash has, whether singly or in any combination, proved much more useful than either of the other fertilizers used. There is much evidence in the behavior of the crops this year, during the growing season and in the results, that this salt is proving injurious in its chemical effect upon the soil. I believe this effect to be a loss of lime in the form of chloride by leaching, but cannot regard this as yet proven. I will present the facts apparently bearing upon the case, and leave full discussion to a later report.

1. During the early part of the growing season the corn upon all the plots which had received muriate of potash was distinctly behind that upon other plots.

2. As the season advanced, the corn upon these plots gradually lost its sickly appearance, gained upon that in the other plots, eventually excelling, in the case of the plot receiving nitrogen, phosphoric acid and potash, that in all other plots except the manure plot.

3. This unhealthy appearance of the corn early in the season, followed by great improvement later, is analogous to effects noticed in other experiments,* where chlorides have been used, and where liming the land has remedied the faulty condition.

* For example, Plot 6, Field A. See report State Experiment Station for 1896.

4. On that plot receiving dissolved bone-black as well as muriate of potash, the crop was in the end a good one. As is well known, the dissolved bone-black contains a large amount of sulphate of lime. It is believed that this may take the place of the lime leached from the soil as a consequence of the use of the muriate of potash, or at least that it corrects in some way the faulty condition consequent upon the use of this salt. It may here be pointed out that a similar corrective influence is evident in the results obtained both in 1897 and 1898 upon our other home-test acre, which will immediately be discussed.

It is of interest, further, to point out that the crop this year upon the lime plot was not quite equal to the average of the nothing plots, while that of the plaster plot (sulphate of lime) was about double that of the lime plot. In the earlier years of this soil test the yield of neither the lime nor the plaster plot ever exceeded that of the nothings, but for the past three years the plaster plot has been relatively gaining. The explanation of this difference between the effect of plaster and lime is not apparent. It will be made the subject of future study.

Conclusions.

1. The yield of the plot which for ten years has received only phosphoric acid and potash (41.2 bushels per acre) illustrates in a striking way the comparative independence of the corn crop of supplied nitrogen upon this soil.

2. The crop raised where nitrogen, phosphoric acid and potash have been yearly applied (nitrate of soda, dissolved bone-black and muriate of potash) for ten years shows that profitable results may be obtained by the use of fertilizers alone. The yearly cost of the application to this plot has been from $10 to $12. The crops have not been much inferior to those on the plot to which manure at the rate of 5 cords per acre has been yearly applied. The two crops this year are, respectively: for the fertilizer, 55.9 bushels; for the manure, 67.7 bushels. The extra 11 bushels of corn will not cover the added cost of the manure, as compared with the fertilizer; and in earlier years the differences in yield have been relatively much smaller than this year.

3. The problems suggested by the results of the year must be regarded as the most valuable product of this experiment. These problems are not solved. Their solution will throw important light upon methods to be employed in compounding and selecting fertilizers.

2. *Soil Test with Onions. Amherst.*

This experiment occupied a field which has been employed in work of this kind for nine years, the several plots having been every year manured alike, as described under the "Soil test with corn." The crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, and potatoes. The land was ploughed in the fall of 1897, and sown with winter rye as a cover crop. The rye was turned in before it had made much of a spring growth, April 21. Fertilizers were employed this year in double the usual quantities; viz., nitrate of soda at the rate of 320 pounds; dissolved bone-black, 640 pounds; and muriate of potash, 320 pounds, per acre. These fertilizers are each used upon one plot singly, in pairs, and upon one plot all three together.

The seed was sown in the customary manner, but more thickly, on May 9. Germination was prompt and perfect. The development of the crop throughout the season was most suggestive in problems for future solution. At the start plants upon the four plots, potash alone, potash and bone-black, potash and nitrate, and potash with both bone-black and nitrate, were much ahead of those on the plots not manured with potash. There was every indication that this element would almost entirely control the crop, for there was good growth wherever potash was applied, and but feeble growth elsewhere. The potash plots, however, after about four weeks, began to lose their superiority; and it was not long ere many of the plants upon these plots became manifestly very unthrifty, and before the end of the season many of them had died. Meanwhile, the phosphoric acid plots began to gain; and the results show that this, more than either the nitrogen or the potash supply, con-

trolled the product. The crop was very light, however, even upon the best plot, which was at the rate of 116.9 bushels per acre, upon the plot receiving nitrate of soda and dissolved bone-black. Upon the plots receiving these two fertilizers and muriate of potash the crop amounted to only 16.3 bushels per acre. Here is strong evidence that the muriate of potash has produced in the soil of this field conditions absolutely prejudicial to the growth of the onion.

Last year this field was in potatoes under the same system of manuring, but with half the quantities employed this year. The crop of potatoes on the nitrate and bone-black was much heavier than on these two and potash, and in commenting upon this fact in my annual report I wrote: "The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which these two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must, therefore, conclude that some disturbing factor, at present unknown, influenced the results."

In view of the similar relative results upon the two plots under discussion this year, I am now forced to conclude that I was mistaken last year in supposing that the superiority of the plot receiving nitrogen and phosphoric acid only was not "the effect of the fertilizer alone."

I now believe that the muriate of potash has proved actually injurious to the last two crops, and that the explanation (the loss of lime which it causes) already suggested accounts for this effect.

The Proper Course as regards Potash Supply.

What, then, in view of such results, are we to recommend? Clearly not to cease using potash, — we have been unable to raise good crops without it. It is believed the remedy will be found in one of three directions; viz., (1) the occasional liberal use of lime where muriate of potash is employed; (2) the use of other potash salts, such as carbonate or sulphate; or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulphate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, supply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

Again, in conclusion it may be said the most profitable results of the year's work are the suggestions for future lines of work, which, being completed, must throw much needed light upon the problems connected with the use of fertilizers.

3. Soil Test with Oats. Norwell.

The past was the third season of soil test work upon this acre, the two preceding crops having both been corn. The results with both of the tests with corn have indicated a strong demand for potash by corn on this soil. These results were thus in entire agreement with those obtained in almost all of the large number of soil tests with this crop that during the past ten years have been carried out under my direction in all the counties of the State.

The results the past season with oats seem also to be in general accord with results previously obtained in other sections with this crop. This is not shown clearly by the figures giving the yields, for the reason that excessive rains flooded parts of the field which is nearly flat soon after the seed was sown, rendering germination poor and uneven.

From examination during the growing season I feel certain that in this experiment it was the nitrate of soda which most largely benefited the crop. The crop on dissolved boneblack was at the rate of 9.7 bushels per acre; on dissolved

bone-black and nitrate of soda it was 13 bushels. On muriate of potash the crop was 10 bushels; on the muriate and nitrate of soda it was 13.6 bushels. On the bone-black and muriate of potash the crop was at the rate of 9.8 bushels per acre; on these two fertilizers and nitrate of soda it was 17.8 bushels. The soil is clearly in need also of both phosphoric acid and potash for good crops, although the figures of this year afford no certain index to its condition, owing to the damage by water above mentioned.

4. *Soil Test with Oats. Montague.*

The present is also the third season of soil test work upon this soil, the preceding crops having been corn, which, owing to accidental conditions, did not give decisive results. The experiment of the past season is eminently satisfactory. The five nothing plots have given fairly even crops, varying from 18.8 to 24.4 bushels per acre of grain, averaging 21.5 bushels; while the straw yield has varied on these plots from 1,470 to 1,830 pounds, averaging 1,554 pounds, per acre. The crop on nitrate of soda alone was 30.3 bushels of grain and 2,210 pounds of straw; on dissolved bone-black, 24.4 bushels and 1,550 pounds; on muriate of potash, 21.3 bushels and 1,470 pounds. This marked increase on the nitrate of soda, as compared with the almost complete absence of effect of the other fertilizers used alone, is striking.

The dissolved bone-black and muriate of potash together gave 23.8 bushels of grain and 1,810 pounds of straw. Again we see practically no effect; but when we use nitrate of soda with these two fertilizers, we have a crop of 31.3 bushels of grain and 2,710 pounds of straw. Nitrate of soda with muriate of potash gives 30.3 bushels and 2,350 pounds, and with dissolved bone-black it gives 31.3 bushels and 2,330 pounds.

It will be seen, then, that in this experiment it was the nitrate of soda alone which proved effective. Alone and in all its combinations it gave a large increase in crop, and in all cases practically the same. The average increase apparently due to the use of this fertilizer amounted to 8 bushels of grain and 804 pounds of straw. The average increases ap-

parently due to the use of dissolved bone-black were 2.1 bushels of grain and 193.4 pounds of straw; those apparently due to the muriate of potash were 1 bushel of grain and 175 pounds of straw.

Manure at the rate of 5 cords per acre gave about 806 pounds more straw, but only .7 bushels more grain than the complete fertilizer, costing some $13 per acre less; and the manure crop did not indeed surpass the crop on nitrate of soda alone in much greater degree. The latter application cost $3.20 per acre, while the manure can scarcely be estimated at less than $25.

This Montague experiment is one of the most perfectly satisfactory in a long series of such experiments; and it is a pleasure to see that its teaching as to the value of nitrate of soda for the oat crop is so entirely in agreement with that of other experiments with this crop.

For convenience is appended a statement giving the arrangement of plots and the system of manuring in nearly all our soil test work, which now extends over ten seasons: —

Plot 1, nothing.
Plot 2, nitrate of soda, 160 pounds per acre.
Plot 3, dissolved bone-black, 320 pounds per acre.
Plot 4, nothing.
Plot 5, muriate of potash, 160 pounds per acre.
Plot 6, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre.
Plot 7, { nitrate of soda, 160 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 8, nothing.
Plot 9, { dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 10, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 11, plaster, 160 pounds per acre.
Plot 12, nothing.
Plot 13, manure, 5 cords per acre.
Plot 14, lime, 160 pounds per acre.
Plot 15, nothing.

Manure Alone *v.* Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a smaller application of manure used in connection with muriate of potash was begun in 1890. A full account will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn of 1896. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash was used in 1897. The field includes four plots, of one-fourth an acre each. The average results for 1897 are shown below: —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92; 4 cords, 1893–96; and potash, 160 pounds per acre): hay, 961¼ pounds; rowen, 536½ pounds.

This field was continued in grass and clover during the present season, but manure and potash were applied as shown below: —

Plot 1, manure, 1 cord; weight, 5,087.5 pounds.

Plot 2, { manure, .5 cord; weight, 2,712.5 pounds.
muriate of potash; weight, 40 pounds.

Plot 3, manure, 1 cord; weight, 5,372.5 pounds.

Plot 4, { manure, .5 cord; weight, 2,855 pounds.
muriate of potash; weight, 40 pounds.

The manure applied to each plot was sampled and analyzed, and from the analyses the amounts of the three most essential elements of plant food applied per acre were calculated, with results shown below: —

Manurial Ingredients per Plot.

Plots.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plot 1, in manure,	20.9	14.2	25.9
Plot 2, in manure,	11.4	6.2	15.2 } 35.1
Plot 2, in muriate of potash,	–	–	19.9 } 35.1
Plot 3, in manure,	22.0	15.0	26.9
Plot 4, in manure,	15.1	9.7	18.0 } 37.9
Plot 4, in muriate of potash,	–	–	19.9 } 37.9

The manure was applied on April 1, the muriate of potash to plots 2 and 4 on April 9.

During the later growth of the mixed grasses and clovers upon these plots it was plainly evident that the clover was relatively more prominent upon plots 2 and 4. The first crop was cut on June 20; the second, on August 26, and both were secured in excellent condition.

Yield per Plot.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1,	1,395	840
Plot 2,	1,120	730
Plot 3,	1,460	810
Plot 4,	1,497	830

Average Yield per Acre.

Plots 1 and 3 (manure alone),	5,710	3,300
Plots 2 and 4 (manure and potash),	5,235	3,120

Combining the figures showing the yields in hay and rowen, we find that the average of plots 1 and 3 is at the rate of 9,010 pounds per acre; and of plots 2 and 4, 8,355 pounds. There is, then, a difference of 655 pounds only in total yields per acre, in favor of the large application of manure alone. This amount is quite insufficient to cover the larger cost of the acre application ($6.80 in the case of

the manure alone). This field has now been broken up, and will next year be put once more into corn, when it is believed the beneficial effect of the large growth of clover upon plots 2 and 4 will become apparent.

"Special" Corn Fertilizer v. Fertilizer Richer in Potash.

This experiment was begun with a view to comparing the results obtained with a fertilizer proportioned like the average "*special*" *corn fertilizers* found upon the markets in 1891 with those obtained with a fertilizer richer in potash, but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots of one-fourth of an acre each. The materials supplied to the several plots are shown in the following table: —

Fertilizers.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	20.0	18.0
Dried blood,	30.0	30.0
Dry ground fish,	30.0	20.0
Plain superphosphate,	226.0	120.0
Muriate of potash.	22.5	60.0
Cost of materials per plot,	$3 23	$3 10

In 1897 the average (both hay and rowen) produced by plots 1 and 3 was 873.5 pounds, or 3,494 pounds per acre; on plots 2 and 4, 860.5 pounds, or 3,442 pounds per acre. This difference is too small to be of practical significance. The rowen crop was heavier on plots 2 and 4 than on plots

1 and 3, showing an apparent influence of the greater amount of potash used on these plots in a larger proportion of clover.

For the present season the fertilizers were applied as last year, being evenly broadcasted on April 11. The first crop was cut June 21. It consisted largely of red-top, which was then not fully in bloom. The second crop was cut August 26. Both crops were well secured, and the yields are shown below: —

Yield of Hay and Rowen, 1898.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1 (lesser potash),	670	530
Plot 2 (richer in potash),	585	440
Plot 3 (lesser potash),	540	365
Plot 4 (richer in potash),	550	415

Average Rates per Acre.

Plots 1 and 3,	2,420	1,790
Plots 2 and 4,	2,270	1,710

We have then, as will be seen, an average product, from the application richer in nitrogen and phosphoric acid, at the rate of 150 pounds of hay and 80 pounds of rowen per acre more than from the application poorer in these elements and richer in potash. It is believed that the failure of plots 2 and 4 to show greatly superior development of clover is in part due to variations in physical characteristics of the soil of the different plots, leading to unfavorable moisture conditions, which prevented an even catch of clover on plots 2, 3 and 4, but did not injuriously affect Plot 1. Further, it should be pointed out that results which will be published later in this report in the case of clover experiments on a series of plots manured alternately with muriate of potash and with sulphate of potash indicate that the long-continued use of muriate of potash in liberal amounts without liming is unfavorable to the healthy development of clover. This field has now been broken up, and will be again put into corn next season.

Leguminous Crops (Clover, Pea and Bean or "Pod" Family) as Nitrogen Gatherers. (Field A.)

This experiment is a continuation of a series begun in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure as sources of nitrogen.*

The plots, eleven in number, are one-tenth acre each, and are numbered 0 to 10. Three plots (4, 7 and 9) have received no nitrogen-containing manure or fertilizers since 1884; one (0) has received farm-yard manure; two (1 and 2), nitrate of soda; three (5, 6, and 8), sulphate of ammonia; and two (3 and 10), dried blood every year since 1889. These materials have been used in amounts to furnish nitrogen at the rate of 45 pounds per acre each year.

All the plots have received yearly equal quantities of phosphoric acid and potash; viz., 80 pounds per acre of the former and 125 pounds of the latter from 1889 to 1894 and the past two seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulphate; to others, in the form of muriate. The results with the former salt have been superior to those with the latter, as a rule, particularly when used in connection with sulphate of ammonia.

Up to this year we may briefly characterize the results, in so far as these have a bearing upon the two main questions proposed, as follows: —

1. The leguminous crops grown (soy beans in 1892, 1894 and 1896) have not appeared to enrich the soil in nitrogen, if we accept the results with the next following crop as affording a basis of judgment.

2. The different sources of nitrogen have ranked on the

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* Only such details are given here as are necessary to an understanding of the nature of the experiment. Full particulars will be found in our ninth and tenth annual reports.

average in the following order: nitrate of soda, farm-yard manure, dried blood and sulphate of ammonia.

After the oat crop of 1897 was harvested the land was ploughed, and late in July sown to Mammoth red clover. Germination was quick and good; but the young plants on all plots failed to flourish, and soon took on a most unhealthy appearance on all except the manure plot, and even on this their development was not what could be desired. In April of this year the plots were most carefully examined, and the clover ranked as follows: plot 0, good; 1, fair; 2, poorer than 1; 3, like 2; 4, mostly dead; 5, all dead; 6, all dead; 7, like 2; 8, best in field (limed in 1896); 9, like 2; 10, somewhat better than 2.*

The general average of condition was so poor that it was decided to plough the field, which was done on April 18. From previous observations upon this series of plots it was decided that liming was called for, and accordingly 200 pounds per plot of partially air-slaked lime was spread on and harrowed in on April 20. Eight hundred pounds of manure was applied to plot 0 on April 23, and on April 26 the fertilizers were applied.

The plots were all sown to Clydesdale oats on April 27, 8½ pounds per plot. The analysis of the manure and a table showing fertilizer treatment and yields follow: —

Analysis of Manure Used.

	Per Cent.
Moisture,	72.53
Nitrogen,	.43
Phosphoric acid,	.16
Potash,	.26

* For manuring of these plots, see page 58.

Nitrogen Experiment. — Fertilizer Treatment and Yields of Oats, 1898.

PLOTS	FERTILIZERS.	Pounds.	Weight of Oats (Pounds).	Weight of Straw (Pounds).	Bushels Oats per Acre.	Weight of Straw per Acre (Pounds).
Plot 0,	Barn-yarn manure, . . Potash-magnesia sulphate, . Dissolved bone-black, . .	800.0 32.0 18.0	83.0	125	25.90	1,250.0
Plot 1,	Nitrate of soda, . . . Potash-magnesia sulphate, . Dissolved bone-black, . .	29.0 48.5 50.0	103.0	150	32.20	1,500.0
Plot 2,	Nitrate of soda, . . . Potash-magnesia sulphate, . Dissolved bone-black, . .	29.0 48.5 50.0	115.0	175	35.90	1,750.0
Plot 3,	Dried blood, . . . Muriate of potash, . . Dissolved bone-black, . .	43.0 25.0 50.0	96.0	155	30.00	1,550.0
Plot 4,	Muriate of potash, . . Dissolved bone-black, .	25.0 50.0	56.0	80	17.50	800.0
Plot 5,	Ammonium sulphate, . . Potash-magnesia sulphate, . Dissolved bone-black, . .	22.5 48.5 50.0	103.0	135	32.20	1,350.0
Plot 6,	Ammonium sulphate, . . Muriate of potash, . . Dissolved bone-black, . .	22.5 25.0 50.0	109.0	160	34.10	1,600.0
Plot 7,	Muriate of potash, . . Dissolved bone-black, .	25.0 50.0	72.5	95	22.70	950.0
Plot 8,	Ammonium sulphate, . Muriate of potash, . . Dissolved bone-black, .	22.5 25.0 50.0	123.0	155	38.40	1,550.0
Plot 9,	Muriate of potash, . . Dissolved bone-black, . .	25.0 50.0	76.5	95	23.90	950.0
Plot10,	Dried blood, . . . Potash-magnesia sulphate, . Dissolved bone-black, . .	43.0 48.5 40.0	112.0	135	35.00	1,350.0
Average of no-nitrogen plots, ...					21.40	900.0
Average of muriate of potash plot (as far as comparable), . . .					32.05	1,595.0
Average of sulphate plots (as far as comparable), ...					35.20	1,416.7

It is important to point out that the oats on the several plots ripened at different times. An effort was made to harvest the crop upon all at the same stage of maturity. With this end in view, plots 1, 2 and 5 were cut on July 29; plots 6, 8, 9 and 10, on July 30; and the balance on August 2. Meanwhile, there had occurred the phenomenally heavy rain and wind of July 30, P.M., and numerous other heavy showers; moreover, the weather continued per-

sistently bad much of the time until the middle of August, and there was much loss through shelling of the grain. The straw, therefore, perhaps better than the grain, affords an index to the relative value of the several manurings. The rank of the different sources of nitrogen, taking straw production as the basis of estimation, is nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure.

After the oats were harvested the land was ploughed, and without further manuring sown to Mammoth red clover, which at the time winter set in was in excellent condition.

The reader will naturally, perhaps, conclude that the better condition of the clover this year as compared with last is a consequence of the liming, and I am of opinion that this may be the case; but nevertheless I cannot regard this as certain, for the reason that upon Field B (reported upon below), where clover sown in the summer of 1897 failed, we have now an excellent stand of this crop obtained by sowing seed where it had failed this spring, without liming or reploughing.

Muriate *v.* Sulphate of Potash for Clover. (Field B.)

Field B is laid off in eleven equal plots, of two-fifteenths of an acre each. The manuring has been uniform since 1884. These plots are numbered from 11 to 21. *Every year each plot has received an application of ground bone at the rate of 600 pounds per acre. The odd-number plots have yearly received muriate of potash and the even-number plots the high-grade sulphate, in each case at the uniform rate of 400 pounds per acre.* This series of plots has produced a great variety of crops, including potatoes, corn, grasses, oats and barley each, with vetches, rye and clovers. The crops have been generally excellent. Full details will be found in the tenth and twelfth annual reports of the State Experiment Station, and the reports of the Hatch Experiment Station for the last three years. In the summer of 1895 two plots (one muriate the other sulphate) of each of the following clovers were sown: sweet clover (*Melilotus alba*), mammoth red clover, medium red clover and alsike

clover. Between the crops produced respectively on the muriate and sulphate of potash no marked difference in yield was observed in either 1896 or 1897. It was, however, noticed in 1896 that the clover raised on the sulphate of potash was richer in starch and similar extractive substances, in the case of the mammoth, medium and alsike clovers, than that raised on the muriate, thus making the sulphate clover the more valuable.

Bad Effect of the Muriate.

In August of 1897 the plots were ploughed and all again seeded to the same varieties of clover. Germination was excellent, but within a very few weeks after the young plants appeared it was observed that in the case of the mammoth, medium and alsike varieties the plants were doing very poorly upon the muriate plots. As the autumn advanced, these plants for the most part grew more and more feeble, and many died. The winter was favorable to newly seeded land; but in the spring it was found that a large proportion of the plants upon the muriate plots were dead, in the case of the varieties above named. The sweet clover showed no difference between the two fertilizers. The condition of the clovers upon the sulphate plots was not entirely satisfactory, although far superior to that upon the muriate.

It was decided to sow additional seed upon all the plots without reploughing. Accordingly, on April 2, 4 pounds of seed of the appropriate variety were sown upon each of the plots. The conditions were favorable to germination, and a good stand of young clover was obtained upon all the plots. The sulphate plots gave much the larger yields of clover this season, because they contained a far larger proportion of the older plants from last summer's sowing. At the present time, however, the condition of the clover upon the muriate and sulphate plots is fairly even, for the spring-sown clover has done equally well upon both the potash salts.

This record of facts is made without comment, as without further investigation it appears to be impossible to explain why the summer-sown clover failed on the muri-

ate, while the spring-sown has flourished upon the same plots without reploughing or any change in treatment.

MURIATE *v.* SULPHATE OF POTASH FOR CORN. (FIELD B.)

Two plots in Field B, one muriate and one sulphate, were planted to Sibley's Pride of the North corn, with a view to testing the relative value of these two potash salts for this crop. It will be remembered that these plots have been under the same manurial treatment since 1884. The fertilizers were broadcasted after ploughing, and harrowed in, and the corn was planted on May 30, in drills 3½ feet apart. It was later thinned to 1 foot in the drills. The crop was cut September 9 and husked the middle of October.

Corn on Muriate and on Sulphate of Potash.

MANURING PER ACRE.	Corn (Pounds).	Stover (Pounds).	YIELD PER ACRE.	
			Corn (Bushels).	Stover (Pounds).
Plot 19, { Muriate of potash, 400 pounds, Ground bone, 600 pounds, }	488.5	866	45.8	6,495
Plot 20, { Sulphate of potash, 400 pounds, Ground bone, 600 pounds, }	428.5	652	40.1	4,890

The apparent superiority of the crop raised on the muriate of potash is considerable. During the growth of the crop, as the result of frequent examinations, no such difference was evident; and it is regretted that the moisture test has not been completed in season for this report, as it is felt that there may have been a difference in condition of the two crops when weighed, owing to the very rainy weather of the autumn.

SWEET CLOVER (*Melilotus alba*).

As has been stated under "Muriate *v.* Sulphate of Potash for Clovers," sweet clover occupied two of the plots in Field B. The present is the third successive year that this clover has been grown upon these plots, and the soil appears now to have become thoroughly stocked with the nodular bacteria peculiar to the plant. As reported in 1896, but few of the plants on these plots in that year possessed

bacteria, and only those which did made vigorous growth. The next year, as already reported, about one-half of the plants apparently possessed nodules and made vigorous growth early in the season. Later all seemed to acquire the ability to make use of the atmospheric nitrogen which these nodular bacteria give. The crop of this season has been extremely vigorous from the very first. The rapid growth of this legume in early spring seemed to indicate its possible value as a cover crop for green manuring; and to test this point one square yard (believed to be average) was harvested at each of three different dates, and a determination of dry matter and of nitrogen contained therein was made. The results calculated per acre were: —

Date.	Height (Feet).	Dry Matter (Pounds).	Nitrogen (Pounds).
June 6,	2½	3,661.6	136.8
June 15,	3½	3,961.7	130.2
July 10,	5½	7,573.0	192.5

The crop was in full bloom at the time the last cutting was made, but it goes on blooming freely for almost the entire summer.

Corn for the silo may here be planted up to the middle of June, with a good prospect of success; and, as will be seen, previous to that date the sweet clover makes a large growth and contains a heavy amount of nitrogen. The amount of this element at the date of the second cutting is equivalent to that contained in about 6 cords of rich manure. To what extent, however, this nitrogen has been taken from the soil, and to what extent from the air, our experiments afford us no means for determining. Kühn has pointed out that the acquisition of atmospheric nitrogen by plants of the clover family takes place most abundantly in the later stages of their growth; and that, if they be ploughed under immature, we can hope for but little gain in that element. Our experiment, then, is not conclusive, as yet, as to the value of this clover as a green manuring crop. Since, however, being sown in the latter part of July

or early in August, it will afford winter protection to the soil and furnish a large growth before late corn planting time, it seems worthy of further trial.

Value for Bees.

As is known to many, this clover furnishes an abundant and long-continued supply of honey. For many weeks the plants in our plots were daily visited by countless myriad bees, and the rate of honey production of those kept near by was very rapid, The honey is of good quality.

High-priced Seed an Obstacle to the Use of Sweet Clover.

The high price at which the seed of this clover is at present offered in our markets constitutes a great obstacle to its use as a green manuring crop. Recognizing this fact, and wishing to determine whether the seed might not be more cheaply offered, our crop of this year was allowed to mature. The sulphate of potash plot (two-fifteenths acre) gave a product of 43.5 pounds and the muriate plot 46.5 pounds of rather poorly cleaned seed. It is true that the season was unfavorable to the ripening of the seed; but the indication of this single experiment is that the species can not be counted upon for a liberal seed product, and that, therefore, the seed must remain high in price.

Nitragin, A Germ Fertilizer.

In connection with my report upon sweet clover, it has been shown that in the early attempts to cultivate this crop but partial success was obtained, because the germs of the appropriate nodular bacteria (microscopic plants, which, growing in nodules upon the roots, give the power of assimilating the free nitrogen of the air) were not present in sufficient numbers. It is there pointed out that, after three years' culture of the sweet clover upon the same plots, these bacteria so multiplied in the soil that complete success with the clover followed. Similar results in the first attempts to cultivate plants of the "pod" family (*Leguminosæ*) in localities where they had not been before grown have many times been observed; and many times, also, has ultimate success crowned the effort to produce the new plant, and for the

reason above alluded to. The attainment of success in this manner, however, requires some few years; and time is precious. Recognizing this fact, an attempt to propagate the bacteria connected with nitrogen assimilation artificially and to put them upon the market was some few years ago made by Professor Nobbe of Tharandt, Germany. The effort was successful, and the product, under the name *Nitragin*, has been offered for the past few years by a German firm with which Professor Nobbe completed arrangements for its production and sale. Full particulars concerning *Nitragin*, and directions for its use, will be found in our eleventh annual report. The unsuccessful results of its trial upon clover in 1897 are published in our last annual report.

The scientific standing of Professor Nobbe is such and the general importance of the subject so great that further trials and with other plants seemed desirable. Accordingly, nitragin for the following species was ordered direct from the makers: crimson clover, red clover, alfalfa, sweet clover, soy bean, vetch and pea.

The experiments are not yet complete, but are being carried out upon poor plain land hired for the purpose, where most of these crops have never been cultivated, as well as upon our own grounds. The plan of the experiment upon the plain land is shown below.

Plan of Nitragin Experiments.

The plots are one-twentieth of an acre each, duly separated by dividing strips. The treatment of the several plots for each crop will be clear from the table: —

Plot 1, no fertilizers. No nitragin.
Plot 2, no fertilizers. Nitragin.
Plot 3, { acid phosphate, 400 pounds per acre. muriate of potash, 250 pounds per acre. lime, 1,000 pounds per acre, } No nitragin.
Plot 4, manurial treatment, like Plot 3. Nitragin.
Plot 5, same manures as 3, and, in addition, 180 pounds per acre of nitrate of soda. No nitragin.

The plan upon the home grounds is similar, with two exceptions: (1) The plots are smaller, and (2) there are no plots left unfertilized.

The crops started in the spring upon the "plain" include field peas, alfalfa, alsike clover and common red clover. The peas were harvested early in August. The yields of the several plots were very small, and showed no favorable influence from the nitragin. Of all the other crops, it can be reported to-day that the general condition is poor; that the best condition is to be found in every case upon Plot 5 (supplied with available fertilizer nitrogen), and that the crop upon mineral fertilizers with nitragin (4) appears somewhat better than the corresponding plot (3) without nitragin. Between plots 1 and 2 there appears to be no appreciable difference.

Upon our home grounds the field pea with nitragin gave a slightly better crop on mineral fertilizers alone than on mineral fertilizers without nitragin. Alfalfa upon mineral fertilizers and nitragin now looks better than on the same fertilizers without nitragin. It will be seen, then, that thus far the experiments of this season afford indications that some slight benefit has followed the use of this germ fertilizer.* Of the crops sown in late summer it is as yet too early to report.

Fertilizers for Garden Crops.

This series of experiments, begun in 1891, was originally intended to test the value for the different garden crops of nitrate of soda, sulphate of ammonia and dried blood as sources of nitrogen; but in the second year it was made to include also a comparison of muriate with sulphate of potash, each used with each of the three nitrogen fertilizers, for the same class of crops. Dissolved bone-black has been applied equally to all the plots from the first. The number of plots and the fertilizers annually applied to each up to the present year are shown in the following table: —

* It may be useful, though this fact has already many times been pointed out, to remark here that a third, and often very satisfactory, method of securing a stock of nodular bacteria consists in taking earth from soil where the crop under trial flourishes, and incorporating a little, as one might fertilizer, with the soil where the new crop is to be grown. This method is now under trial here with alfalfa with soil from Kansas.

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply, at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The management of the experiment and results and conclusions are presented in great detail in our eighth, ninth and tenth annual reports, and to these the student of these experiments is referred. It suffices for our present purpose to call attention to the general results up to the end of the year 1897, which are shown below: —

Averages of Garden Crops, 1892 to 1897, inclusive.

Plots.	Spinach, grown Three Years (Pounds).	Lettuce, grown Three Years (Pounds).	Tomatoes, grown Four Years (Pounds).	Beans, grown Three Years (Pounds).	Onions, grown Two Years (Pounds).	Sweet Corn, grown Two Years (Pounds).	Green Peas, grown One Year (Pounds).	Table Beets, grown Two Years (Pounds).
Plot 1,	153	37	482	43	111	144	177	255
Plot 2,	210	43	707	49	326	179	203	479
Plot 3,	182	42	577	50	259	160	281	372
Plot 4,	196	63	717	44	221	151	348	425
Plot 5,	232	66	790	59	298	143	343	591
Plot 6,	149	41	503	51	235	154	307	483

It is important to point out that none of the crops included above has in any year occupied the whole of the area under experiment. Each year we have had some four or five crops, and the areas in each have varied. The above figures are valuable, then, solely as a basis of comparison between the several plots.

Conclusions based on Results up to 1897.

The chief conclusions which seemed justified by the results above given are the following: —

1. Sulphate of potash in connection with nitrate of soda (Plot 5) has generally given the best crop. In those cases where this has not been true, the inferiority of this combination has usually been small. In one case only has it fallen much behind, viz., with sweet corn, a crop which makes much of its growth in the latter part of the season.

2. Nitrate of soda (plots 2 and 5) has in almost every instance proved the most valuable source of nitrogen, whether used with muriate or the sulphate of potash.

3. The combination of sulphate of ammonia and muriate of potash (Plot 1) has in every instance given the poorest crop. This fact is apparently due, as Dr. Goessmann has pointed out, to an interchange of acids and bases leading to the formation of chloride of ammonia, which injuriously affects growth.

The Experiment in 1898.

In the fall of 1897 the plots were ploughed, and rye sown on all (without further manuring) as a cover crop, chiefly to prevent soil washing. The growth on Plot 1 (sulphate of ammonia and muriate of potash) was sickly and feeble, but no particular difference was noticed between the other plots.

Change in Plan.

In view of the fact that market gardeners, in whose interests chiefly these experiments are being carried out, almost invariably use large quantities of stable manure, and employ fertilizers, if at all, simply to supplement the manure, it was decided to make a change in the plan of the experiment, in order that the conditions under which we are working may more nearly conform to those of the average market gardener.

Accordingly, it was decided to apply equal amounts of thoroughly mixed stable manure to each plot, and to use on each, in addition, the same fertilizers as heretofore. Further, in order to have a basis for determining whether the fertilizers should prove in any degree useful, another plot was added, to which manure alone is applied. It was impossible to secure for this purpose a plot of exactly the same shape as the others, and of course it has not had the same history. It is, however, contiguous, and it has the same elevation and similar soil. This plot, which will be called plot 0, has for the past fifteen years received an annual application at the rate of ground bone 400 pounds and muriate of potash 200 pounds per acre. It has been planted yearly with a variety of the newer forage crops. Manure was applied at the rate per acre of twelve cords to all of the seven plots. The manure was applied by measure, but it was also weighed. The table shows the weight applied to each plot and the quantities of plant food which it carried : —

PLOTS.	Manure (Pounds).	Nitrogen (per Cent.).	Potassium Oxide (per Cent.).	Phosphoric Acid (per Cent.).
Plot 0, ...	6,720	28.8960	10.7520	17.4720
Plot 1, ...	6,977	30.0011	11.1632	18.1402
Plot 2, ...	6,775	29.1325	10.8400	17.6150
Plot 3, ...	7,065	30.3795	11.3040	18.3690
Plot 4, ...	6,617	28.4531	10.5872	17.2042
Plot 5, ...	7,210	31.0030	11.5360	18.7460
Plot 6, ...	6,945	29.8635	11.1120	18.0570
Manure contained, ...	–	.0043	.0016	.0026

Details.

The manure was evenly spread upon the surface April 18–23. The land was ploughed April 27, a thin crop of rye, previously alluded to, being turned under. The fertilizers were applied evenly, broadcast as in previous years, on May 2, and harrowed in. The land was once more harrowed on May 5. Throughout the season all plots received clean culture.

The crops the past season have been: strawberries (Clyde), spinach, lettuce, table beets, tomatoes, cabbage, celery and potatoes; and, as a second crop, turnips.

Clyde Strawberries. — Three rows were set in each plot. The growth was vigorous and healthy on all plots. Plots 4, 5 and 2 now show a slight superiority over the others, while Plot 0 is the poorest. All are well stocked, in matted rows.

Long Standing Spinach. — Three rows of this crop were planted in each plot May 7. All germinated well, but by June 9 many plants were dying on plots 1 and 4 (sulphate of ammonia and muriate of potash, and sulphate of ammonia and sulphate of potash), while nearly all the plants in these plots appeared yellow and sickly. All the spinach was harvested in two cuttings. The yields in pounds were as follows: Plot 0, 69; Plot 1, $1\frac{1}{4}$; Plot 2, $156\frac{1}{2}$; Plot 3, $77\frac{3}{4}$; Plot 4, $13\frac{1}{2}$; Plot 5, $159\frac{1}{2}$; Plot 6, $73\frac{3}{4}$.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (Plot 0),	88.7
Average of manure and muriate of potash (plots 1, 2 and 3),	78.5
Average of manure and sulphate of potash (plots 4, 5 and 6),	82.3
Average of manure and sulphate of ammonia (plots 1 and 4),	7.4
Average of manure and nitrate of soda (plots 2 and 5),	158.0
Average of manure and dried blood (plots 3 and 6),	75.8

It will be noticed that the muriate of potash plots are inferior to those receiving sulphate of potash, though the difference is small. The sulphate of ammonia plots proved almost an absolute failure, while the dried blood gave a much smaller crop than the nitrate of soda. The most important fact brought out is the marked superiority of the latter as a source of nitrogen for spinach.

Hanson Lettuce. — Two rows of this crop, planted May 7, were grown in each plot, the plants being brought by

* To enable the reader the better to make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulphate of potash," etc. It should be remembered that dissolved bone-black was applied to all except Plot 0, and that every plot received material supplying both nitrogen and potash as well as phosphoric acid in addition to the manure. For the full list of fertilizers applied to each plot, see page 66.

thinning and resetting to a uniform distance of 1 foot in the rows, except on plots 1 and 4, where a large number of the plants died soon after coming up. In harvesting, the heads of market size were cut from day to day. The total crop in pounds on the several plots was: Plot 0, 179¼; Plot 1, 40; Plot 2, 194¼; Plot 3, 220¾; Plot 4, 135; Plot 5, 219; and Plot 6, 231¼.

The average yields, in pounds, produced by the different fertilizers were: —

Manure alone (Plot 0, *corrected for area*),	230.5
Manure and muriate of potash (plots 1, 2 and 3),	151.7
Manure and sulphate of potash (plots 4, 5 and 6),	195.1
Manure and sulphate of ammonia (plots 1 and 4),	87.5
Manure and nitrate of soda (plots 2 and 5),	206.6
Manure and dried blood (plots 3 and 6),	226.0

The manure alone gave, as will be seen, a larger yield than any of the plots to which fertilizers as well as manure were applied. The only point clearly indicated is the apparent highly injurious effect of the sulphate of ammonia, particularly where used with the muriate of potash.

Dewing's Blood Turnip Beet. — Six rows of this crop, planted May 7, were grown in each plot. In plots 1 and 4 most of the plants soon became weak and sickly and many died, and there were not enough to restock to the uniform distance of 4 inches in the row, to which all the other plots were brought by thinning and resetting where needed. The few plants in plots 1 and 4 which survived until about July 1 then appeared to recover their vigor, and grew very rapidly. The yields of roots and tops were as shown below: —

Plots.	Beets (Pounds).	Tops (Pounds).
Plot 0,	340	440
Plot 1,	80	160
Plot 2,	440	570
Plot 3,	365	515
Plot 4,	260	470
Plot 5,	460	490
Plot 6,	325	335

The average yields in pounds per plot were as follows : —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	374.7	484.9
Manure and muriate of potash (plots 1, 2 and 3),	295.0	415.0
Manure and sulphate of potash (plots 4, 5 and 6),	348.3	431.7
Manure and sulphate of ammonia (plots 1 and 4),	170.0	315.0
Manure and nitrate of soda (plots 2 and 5),	450.0	530.0
Manure and dried blood (plots 3 and 6),	345.0	425.0

The general result here is similar to that with spinach; *i.e.*, muriate is inferior to the sulphate of potash; nitrate of soda is the best source of nitrogen; and sulphate of ammonia shows itself to have been actually injurious, particularly so with muriate of potash.

Dwarf Champion Tomato. — Two rows were set in each of the original six plots and three in Plot 0, the plants, purchased of the Horticultural Department, being rather small and uneven. The crop was picked as it ripened until September 23, when the balance of the fruit was picked green. The weights of ripe and of green fruit in pounds per plot are shown below :* —

Plots.	Ripe Fruit.		Green Fruit.	
	Lbs.	oz.	Lbs.	oz.
Plot 0,	422	3	179	8
Plot 1,	387	7	223	0
Plot 2,	501	4	160	0
Plot 3,	328	2	178	0
Plot 4,	430	6	181	0
Plot 5,	413	1	84	8
Plot 6,	405	4	181	8

The averages of ripe fruit and total yield in pounds per plot were as shown in the table : —

* The record of one day's picking of ripe fruit was lost, but this does not change the relative standing of the plots.

	Ripe Fruit.	Total.
Manure alone (Plot 0, corrected for area),	361.9	515.7
Manure and muriate of potash (plots 1, 2 and 3),	405.6	592.6
Manure and sulphate of potash (plots 4, 5 and 6),	416.2	565.2
Manure and sulphate of ammonia (plots 1 and 4),	408.9	610.9
Manure and nitrate of soda (plots 2 and 5),	457.2	579.4
Manure and dried blood (plots 3 and 6),	366.7	546.4

The differences brought out by these averages are much smaller than in the case of the spinach and beets, but are in the same direction for ripe fruit; *i.e.*, sulphate of potash gives somewhat better returns than muriate, and nitrate of soda gives the largest yield of any of the sources of nitrogen. It is noteworthy that the sulphate of ammonia does not appear to have injuriously affected this crop. This is perhaps due to the fact that the tomato is not set until about the first of June, and makes most of its growth when the season is well advanced. The crops shown to have been injured by the sulphate of ammonia, spinach and beets, are sown early, and make most of their growth before the season is far advanced.

Fotler's Drumhead Cabbage. — Two rows in each of the original six plots and three in Plot 0 were grown. The seed was planted May 23, in hills, and later thinned to one in each hill, those destroyed by maggots being replaced. Owing to the unusually hot season, the crop was well grown by September 1, and numerous heads were beginning to crack. They were harvested as they matured, September 8 to November 5. The yield in pounds of heads, practically all well filled and hard, was as follows: Plot 0, 729; Plot 1, 720; Plot 2, 780; Plot 3, 710; Plot 4, 755; Plot 5, 744; and Plot 6, 651.

The average yields in pounds per plot were as follows: —

Manure alone (Plot 0, corrected),	624.9
Manure and muriate of potash (plots 1, 2 and 3),	736.7
Manure and sulphate of potash (plots 4, 5 and 6),	716.7
Manure and sulphate of ammonia (plots 1 and 4),	737.5
Manure and nitrate of soda (plots 2 and 5),	762.0
Manure and dried blood (plots 3 and 6),	680.5

Here we find the fertilizers have apparently produced a moderate increase in crop. The differences between them are far less marked than in the case of most of the other crops grown this year. The nitrate of soda appears to have been the best source of nitrogen for the cabbage.

Early Maine Potatoes. — The seed planted was grown in the State of Maine. It was treated with corrosive sublimate solution, for prevention of scab, and sun-sprouted. Before planting, the tubers were cut to pieces with two eyes each. Three rows per plot (4 on Plot 0) were grown. The seed was planted on May 9 in rows 3 feet apart, the pieces being dropped 1 foot apart in the rows. Ordinary thorough culture was given until the vines covered the ground. The vines were sprayed with Bordeaux mixture (first on June 7) to repel the flea beetle. They were sprayed with sufficient frequency to keep the vines well covered with the mixture until the middle of August, the last application being made August 8. The Bordeaux mixture was applied nine times in all, frequent re-application being necessary, on account of the numerous heavy rains. The vines were slightly attacked by blight about the middle of July; but later in August new shoots were thrown out from the axils of the lower leaves, making a healthy growth, which remained green until very late in September. The tubers averaged large and smooth, and showed very little rot when dug. A few weeks after storing there were a few more decayed tubers. The yield in pounds was as follows: —

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0,	441.5	41.0
Plot 1,	449.0	40.0
Plot 2,	426.0	40.0
Plot 3,	409.0	62.5
Plot 4,	550.0	35.0
Plot 5,	482.0	31.5
Plot 6,	482.0	51.5

Yield per Acre (Bushels).

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0,	381.5	35.4
Plot 1,	447.2	35.8
Plot 2,	381.7	35.8
Plot 3,	366.5	56.0
Plot 4,	492.8	31.4
Plot 5,	431.9	28.3
Plot 6,	431.9	46.1

The averages calculated to show the relative effect of the different fertilizers are given below in pounds per plot: —

Plots.	Merchantable Tubers.	Small Tubers.
Manure alone (Plot 0, corrected),	425.7	39.5
Manure and muriate of potash (plots 1, 2 and 3),	444.7	47.5
Manure and sulphate of potash (plots 4, 5 and 6),	504.7	39.3
Manure and sulphate of ammonia (plots 1 and 4),	524.5	37.5
Manure and nitrate of soda (plots 2 and 5),	454.0	35.8
Manure and dried blood (plots 3 and 6),	445.5	57.0

It becomes evident from a study of these figures that the fertilizers proved moderately beneficial to this crop, and that the sulphate of potash is superior to the muriate. The various sources of nitrogen rank in the order, sulphate of ammonia, nitrate of soda and dried blood, the first giving a much larger average crop than either of the others. It seems further important to point out that the combination sulphate of ammonia with muriate of potash, which has proved both in previous years and in this year so fatal to most crops, has given a fine crop of potatoes, at the rate of 447 bushels to the acre, the second in rank among the seven plots. No explanation can be offered, beyond that already suggested in the case of tomatoes, viz., that the potato has a much longer growing season than the crops doing so very poorly on this combination of fertilizers. It

seems reasonable to suppose that, as the season advances, the injurious ammonium chloride formed at first is either washed out of the soil or destroyed by further chemical changes. This question will be made a matter of further study.

The spraying with Bordeaux mixture, although necessarily nine times repeated on account of the unusual number of heavy rains, must be considered to have been profitable, as the yield was very heavy, while in general the crop this year was light where spraying was not practised.

Giant Pascal Celery. — Two rows were grown in each plot; the plants, large and well grown, were set 1 foot apart in rows 5 feet apart on July 19. Banking began September 29, and the crop was put into the cellar in good condition on November 4. The growth on plots 0, 1 and 4 was fair; on the other plots, excellent. There was considerable rust on Plot 0, while there was little or none on the other plots. The weights in pounds of the plants (including roots and a little earth) were as follows: Plot 0, 443; Plot 1, 328; Plot 2, 478; Plot 3, 478; Plot 4, 348; Plot 5, 568; Plot 6, 488.

The calculated averages will not be given until the crop is blanched, since the earth, of necessity left adhering to the roots of the plants as put into the cellar, is an element of uncertainty. It may be of interest to state that these averages indicate little if any increase which can be attributed to the fertilizers.

White Egg Turnips. — This crop followed spinach, lettuce and table beets, without further manuring. The land was reploughed and fitted and the seed sown on July 28, in rows 14 inches apart. Soon after sowing a heavy shower caused some washing across the plots, which was particularly injurious on Plot 0. The crop was harvested November 8 and 9, and was of excellent quality. The yields in pounds are shown in the following table: —

Plots.	Roots.	Tops.
Plot 0,	580.0	185
Plot 1,	702.0	348
Plot 2,	753.5	315
Plot 3,	735.0	315
Plot 4,	938.0	335
Plot 5,	655.0	260
Plot 6,	690.0	215

The calculated averages in pounds are given in the following table: —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	688.3	219.7
Manure and muriate of potash (plots 1, 2 and 3),	730.3	326.0
Manure and sulphate of potash (plots 4, 5 and 6),	761.0	270.0
Manure and sulphate of ammonia (plots 1 and 4),	820.0	341.5
Manure and nitrate of soda (plots 2 and 5),	704.3	287.5
Manure and dried blood (plots 3 and 6),	712.5	265.0

The fertilizers are shown to have been moderately beneficial, there is not much difference between the two potash salts, and the sulphate of ammonia gives a much better crop than either of the nitrogen fertilizers. This is not strange, in view of these facts: (1) the plots to which this had been applied had produced but very small first crops, while the others had yielded heavily; and (2) that the turnips made their growth so late in the season that the injurious compounds often formed by this salt had become dissipated, or destroyed by further chemical changes.

Experiments in Manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued. We have three large plots (between two and three acres each) under this treatment. Under this system each plot receives wood ashes at the rate of 1 ton

per acre one year; the next year, ground bone 600 pounds and muriate of potash 200 pounds per acre; and the third year, manure at the rate of 8 tons. The system is so planned that each year we have one plot under each manuring. The manure is always applied in the fall, the other materials early in the spring; this year April 8 and 9.

Plot 1, which this year received bone and potash, gave a yield at the rate of 5,137 pounds of hay and 2,370 pounds of rowen per acre. Plot 2, which received ashes, yielded 4,602 pounds of hay and 2,142 pounds of rowen. Plot 3, which was dressed with manure in the fall of 1897, yielded 5,233 pounds of hay and 2,823 pounds of rowen per acre. This field has now been ten years in grass, and during the continuance of the present system of manuring (since 1893) has produced an average product (hay and rowen both included) at the rate of 6,808 pounds per acre. The plots when dressed with manure have averaged 7,211 pounds per acre; when receiving bone and potash, 6,671 pounds per acre; and when receiving wood ashes, 6,541 pounds per acre.

Variety Tests.

Our work in testing varieties this year has been confined to testing the potato. With this it has been extensive. The tests have been of two sorts; (1) a preliminary test with varieties grown for the first time; and (2) a test of the best twenty-five varieties, as indicated by the trial of last year.

1. *Preliminary Test.* — As has been stated in my previous reports upon variety work with the potato, I consider several years' trial necessary to the formation of a judgment. The seed of new varieties as they are brought out must of necessity come from many widely separated localities. Such seed is unfit to serve as a basis for comparison, with the object of determining the relative merits of varieties, as it is well known to many and quite generally admitted that the place where any given variety of seed potatoes is produced may greatly influence its product. Newly obtained varieties must also of necessity have been subjected to widely variant conditions of handling, preservation and

transportation, and all these factors influence product. For all these reasons our practice is to obtain but a small quantity of seed of new varieties as they come to our attention, and to plant this for the purpose of raising seed for the next year's trial, which shall have been produced under similar conditions and similarly handled. This constitutes our "*preliminary test.*"

This test the past season included seventy-five varieties, obtained from almost as many seedsmen, scattered all over New England, the middle and central States and Canada. The seed of all was treated with corrosive sublimate solution and sun-sprouted. It was then cut to pieces of two good eyes each, and planted one piece to a foot, in rows 3 feet apart. The soil was a good medium loam, naturally well drained. The fertilizers used in pounds per acre were: —

Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed just before using, and scattered broadly in the drills before dropping the seed. The planting took place May 11 and 12. All varieties were injured by hot, dry weather, which came just as the tubers were forming, and by blight, although sprayed with Bordeaux mixture six times between June 13 and August 2. The varieties on which blight was first noticed were Salzer's Earliest, Bliss Triumph, King of the Earliest and Lincoln, — July 24 and 25. All other varieties showed blight between July 28 and August 1, and to about an equal degree. It is thought that no varieties blighted long before they were mature; but, nevertheless, the blight undoubtedly greatly reduced the yields. Owing to the blight, the period of apparent ripening of all varieties was nearly the same, viz., August 27 to September 8. The potatoes were dug late in September. The average number of sets for each variety was about forty, and to this number the yield of

all has been corrected. Such correction, in our experience, always proves unduly favorable to the varieties of which we have the least seed. Our effort has always been to obtain just three pounds of each variety; but sometimes we are unable to obtain so much, or it may be that some tubers obtained prove unfit to plant, owing to bruising or decay.

The yield this year has varied from 8.5 to 46.7 pounds of merchantable tubers for 40 sets.* Six varieties have given a yield of 40 pounds or above of merchantable tubers from 40 sets, viz., Ford's No. 31, 46.7; Early Minnesota, 44.7; Champion of the World, 41.8; Burr's No. 1, 40.8; and American Wonder and Early Dawn, 40 each. Eight varieties gave under 20 pounds from 40 sets, viz., Lady Finger, 8.5; Mayflower, 13.9; Salzer's Earliest, 14.2; Potentate, 15.3; Mills's Long Keeper, 16; Livingston's Pinkeye, 16.8; and King of the Earliest and White Beauty, 18.5 each.

2. *Test with Twenty-five Varieties (the Best of Last Season).* — The seed of these varieties, it will be understood, was all of our own growing, and was of most excellent quality. It was prepared for planting as above described, and was planted upon similar soil and similarly manured. One hundred sets of each variety were planted on May 13. These varieties were sprayed six times, as were those in the preliminary test. They, however, showed considerable blight, and doubtless gave diminished yields because of this affection. The yields have been calculated to 40 sets, to make them comparable with the varieties in the other test. These are shown in the table following: —

* Forty pounds for 40 sets corresponds to a yield of 242.4 bushels per acre.
Thirty pounds for 40 sets corresponds to a yield of 181.8 bushels per acre.
Twenty pounds for 40 sets corresponds to a yield of 121.2 bushels per acre.

Variety Test of Potatoes. Yield in Pounds from 40 Sets.

Variety.	Merchantable Tubers.	Small Tubers.
Beauty of Hebron,	33.40	7.00
Bliss's Triumph,	20.40	9.60
Carmen No. 1,	23.40	12.80
Dakota Red,	19.20	10.80
Dutton's Seedling,	32.20	15.20
Early Maine,	21.20	2.80
Early Rose,	28.00	9.00
Early Sunrise,	26.40	10.80
Empire State,	12.40	7.60
Enormous,	36.80	4.20
Fillbasket,	37.60	5.60
Late Puritan,	26.80	9.60
Money Maker,	26.60	7.40
New Satisfaction,	26.60	6.00
Prolific Rose,	28.20	8.00
Restaurant,	34.80	7.60
Rochester Rose,	29.60	8.80
Rose No. 9,	34.00	5.20
Sir William,	26.80	6.20
State of Maine,	34.00	4.80
Thorburn,	35.80	6.40
Uncle Sam,	28.40	3.80
Vanguard,	31.80	9.00
White Elephant,	40.20	8.00
Woodbury's White,	35.90	5.00

Last year the eleven best varieties ranked in yield of merchantable tubers in the following order: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these then gave a product at the rate of more than 220 bushels of merchantable tubers per acre.

This year the relative rank, as will be seen, is quite different. The yields are in general much lower. The results of this year, however, owing to the blight, cannot be re-

garded as affording a reliable index to the relative merits of the varieties. Their publication, however, serves to illustrate how almost impossible it is, in the making of such tests, to establish the relative merits of varieties. As I have remarked in previous reports, it is significant that the old standard, Beauty of Hebron, is once more one of the first ten varieties.

Identical Varieties under Different Names.

As far as we are able to judge, there is no difference between King of the Earliest and Early Ohio; Salzer's Earliest and Bliss's Triumph; Mills's Banner and Livingston's Banner; while White Beauty and Cambridge Russet differ but very slightly, the latter having a slightly more russetted skin than the former.

Test of Seed of the Same Variety from Different Localities.

In order to test the soundness of the *a priori* conclusion that, to make the results of a variety test comparable for the purpose of determining relative merits, the seed of all should have been produced in the same locality and handled in all respects alike, an experiment was carried out with two of the old standard sorts, — Beauty of Hebron and Early Rose, — with seed of each from a considerable number of sources. The seed of the former came from eight different producers; that of the latter, from six. The methods pursued in seed preparation, soil, manuring, spraying, etc., were in all respects as in the variety test.

Comparison of Seed Potatoes from Different Localities. Yield in Pounds of 40 Sets.

Source of the Seed.	Varieties.			
	Beauty of Hebron.		Early Rose.	
	Merchantable.	Small.	Merchantable.	Small.
Home grown,	30.0	2.5	25.0	2.9
Guelph, Ontario, D. of C.,	32.3	1.8	–	–
Pennsylvania grown, Dreer,	24.5	3.3	27.5	3.5
James J. H. Gregory, Marblehead, Mass.,	35.5	2.5	–	–
Cornell Experiment Station, Ithaca, N.Y.,	29.3	2.5	31.0	2.0
Wisconsin, Olds Seed Company,	26.0	4.5	–	–
Maine, A. H. Weeks Company,	33.3	2.8	–	–
Dibble Seed Company, N. Y.,	26.5	3.8	32.5	2.0
Minnesota, Farmer Seed Company,	–	–	21.0	3.8
Kansas, F. Barteldes & Co.,	–	–	20.0	7.8

The range of variation in yield, as will be seen, is large, amounting to almost 50 per cent. in the yield of merchantable tubers for the Beauty of Hebron and to rather over 50 per cent. for the Early Rose. In view of this wide difference in the yield of the same variety, it must be admitted that variety tests in which the seed is brought together from many sources can have but a doubtful value.

The extent of the variation in the type of the potatoes grown in this test was considerable, so great, indeed, as to make it doubtful whether in all cases the seed was true to name, although obtained from the most reliable parties in every instance. The extent of the variation is in part shown in the table below, in which each lot is compared with the crop from our home-grown seed of the same variety: —

Potatoes. — Comparison of Crops, Seed from Different Sources.

Origin of the Seed.	Shape.	Color.	Size.	Eyes.
Beauty of Hebron.				
Home grown, . .	Long, elliptical, slightly flattened, tapering strongly towards tip.	Light flesh, mottled with darker shades.	Medium,	Medium, rather deep.
J. J. H. Gregory, . .	Same, . . .	Same, . . .	Same, .	Smaller, less deep.
Dreer, Pennsylvania, .	Shorter, . . .	Same, . . .	Larger, .	Same.
Olds Company, Wisconsin.	Oval, slightly flat, same at both ends.	Lighter, . . .	Smaller,	Small.
Weeks Company, Maine.	Same, . . .	Same, . . .	Larger, .	Less deep.
Cornell Experiment Station.	Same, . . .	Light, bright pink,	Larger, .	Smaller.
Guelph, Ontario, Experiment Station.	Same, . . .	Same, . . .	Same, .	Same.
Dibble Company, N. Y.,	Same, . . .	Lighter, . . .	Same, .	Same.
Early Rose.				
Home grown, . . .	Long, flattened, tapering towards seed end, curved.	Light pink, bright pink at seed end.	Medium,	Medium large.
Dreer, Pennsylvania, .	Broader, more compact.	Lighter, . . .	Same, .	Same.
Farmer Company, Minnesota.	Much broader, less curved.	Same, . . .	Smaller,	Same.
Cornell Experiment Station.	Longer, more curved.	Same, . . .	Larger, .	Same.
Kansas, Barteldes & Co.,	Broader, more like Hebron.	Same, . . .	Same, .	Smaller, more shallow.
Dibble Company, N. Y.,	Same, . . .	Same, . . .	Larger, .	Large, shallow.

Individual Variation, Tubers of the Same Variety.

In view of the frequently reported tests of varieties in which some two or three tubers only of each are used, it was thought best to carry out an experiment to determine if possible the extent to which the product of single tubers will vary when grown under conditions as favorable as possible to uniformity of yield. As a preparation for this test, tiles two feet in diameter and four feet long were set into the ground in a single row, the distance between them being about two and one-half feet. To insure equal drainage conditions, a drain tile was laid at about the level of the lower edge of the tile, being given just enough pitch to carry off water. The plot of land in which the tiles were set was surrounded with drain tile, to prevent the ingress of soil water from outside. This plot had been uniformly manured for many years, so that the subsoil conditions below the tiles must have been practically uniform. The plots were set so that the surface water from outside was excluded, but the earth outside was brought to within about one inch of the upper edge.

These tiles so set were filled to within one foot of the top with carefully mixed subsoil, consisting of a very fine sand, this subsoil being settled by the liberal use of water. After this subsoil had thoroughly settled and somewhat dried, equal weights of carefully mixed medium loam were put into each tile, the quantities being sufficient to fill them. The amount used was two hundred and twenty-five pounds for each tile. Conclusive evidence that the work was well and uniformly done is afforded by the fact that the earth in the several tiles remained at practically uniform height throughout the season.

With the upper four inches in depth of soil in these tiles were most carefully mixed the fertilizers applied, precisely the same weights as determined by chemical balances to each tile. The materials used supplied per tile and at the rate per acre as follows: —

Materials Used.	Per Tile (Grams).	Rate per Acre (Pounds).
Nitrate of soda,	8.07	250
Dried blood,	3.23	100
Tankage,	8.07	250
Acid phosphate,	12.92	400
Sulphate of potash (high grade),	9.69	300

This fertilizer was applied May 9, and the seed was planted the same day. The variety was Carmen No. 1. The tubers selected were uniform in form, weight and all external characteristics, as far as it was possible to obtain such. The weights of the tubers were as follows: No. 1, 160 grams; No. 2, 135 grams; No. 3, 160 grams; No. 4, 140 grams; No. 5, 135 grams; No. 6, 140 grams; No. 7, 140 grams; No. 8, 140 grams. The first seven tubers were treated with corrosive sublimate solution, and sun-sprouted; No. 8 was not treated. Each tuber was cut to exact halves by weight, and the number of eyes on each half reduced to five in the same part of the tuber. The tubers were all typical of the variety, and all were entirely free from scab, but there had been a few scabbed potatoes in the crop from which they came. They were all planted face downward at the same depth, the halves of tuber No. 1 in tiles 1 and 2, the halves of tuber No. 2 in tiles 3 and 4, and so on, — and finally one-half of tuber No. 8 in tile 15. They all came up in good season, but somewhat irregularly, May 26 to May 28. They were most carefully cultivated by hand, kept entirely free from weeds and from bugs by hand pulling and picking. Bordeaux mixture was applied six times, June 6 to July 25. There was practically no injury from either flea beetle or blight. The vines in different tiles showed quite different minor characteristics, and ripened unevenly, September 20 to October 1, when the crop was harvested. At that time there was a very little yellowish-green color on part of one stalk in tile 9 and on one entire stalk in tile 8. All leaves had for some time been dead. The yields and remarks are given in the table: —

Yield of Different Tubers, Carmen Potato.

No. of Tuber.	Tile.	Number of Tubers.	Weight (Kilograms).*	Remarks.
Tuber No. 1, . . .	1 2	10 14	1.470 1.520	
Tuber No. 2, . . .	3 4	14 11	1.300 1.340	One scabby.
Tuber No. 3, . . .	5 6	15 10	1.440 1.440	Several slightly scabby.
Tuber No. 4, . . .	7 8	12 8	1.180 1.330	Small amount of scab.
Tuber No. 5, . . .	9 10	17 15	1.440 1.620	A very little scab.
Tuber No. 6, . . .	11 12	19 9	1.460 1.340	A little scab.
Tuber No. 7, . . .	13 14	13 14	1.240 1.450	A little scab.
One-half of Tuber No. 8, .	15	16	1.320	Considerable scab.

* The kilogram equals almost exactly 2.2 English pounds.

The above weights were taken after the tubers had been carefully washed and dried. They showed a range of variation amounting between halves to a little over 37 per cent., and between tubers of about 22 per cent. The differences in number and size of tubers are equally striking. In view of these facts, I submit that variety tests of potatoes upon a small scale can have but a small value for determining the probable relative yield of varieties.

Poultry Experiments.

The experiments with poultry completed since our last annual report were begun in the late fall of 1897, and extended through the winter of 1897 and 1898, and a part of them through the past summer and into the fall. The points upon which these experiments were designed to afford information are the following: —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of flesh or animal meal and cut fresh bone.

3. Comparison for egg-production of a wide nutritive ration with a narrow; or, in other words, of a ration in

which corn meal and corn were prominent with one in which these feeds were replaced wholly or in large part with more nitrogenous foods, such as wheat middlings, gluten feed, wheat and oats.

4. The influence of the presence of a cock with the hens upon egg-production.

General Conditions.

In all these experiments pullets purchased in Plymouth County and reaching us about the middle of October were used. These pullets were well-bred Barred Plymouth Rocks, not fancy stock (*i. e.*, as to feather), but bright, healthy stock, hatched in April. These pullets were evenly divided into lots of twenty each, being matched in sets of two lots as closely as possible. Each lot occupied a detached house, including laying and roosting room ten by twelve feet and scratching shed eight by twelve feet, with the run of large yards of equal size whenever weather permitted. The winter tests began December 12 and ended April 30. The latter part of March a few hens were removed from each house for sitters, the same number from each. Egg records of the separate lots were kept from the time laying began to the time of beginning experiments, for the purpose of affording an index as to the equality or otherwise of the matched pairs of lots. The hens were all marked with leg bands, as a precautionary measure for the purpose of identification in the case of accidental mixture of fowls.

All the meals and the cut clover were given in the form of a mash, fed early in the morning. This was mixed the night before with boiling water until January 8, and fed at the temperature of about 70° F. After January 8, the mashes were mixed with boiling water in the morning, and fed hot. At noon a few oats were scattered in the straw with which the scratching sheds were littered. At night the balance of the whole grain was fed (also by scattering in the straw) one hour before dark. The fowls were given what whole grain they would eat up clean. Water, shells and artificial grit were kept before the fowls at all times. About twice a week a small cabbage was given to each lot of fowls, this, like all other food, being weighed. The eggs from each

lot were weighed weekly. The fowls were all weighed once each month.

No male birds were kept in any of the pens in the winter experiments, nor, indeed, in any except where the influence of the cock was the subject of experiment. Sitters, except those taken out, above alluded to, were confined in a coop until broken up, being meanwhile fed like their mates.

The prices per hundred weight for foods, upon which financial calculations are based, are shown below: —

Wheat,	$1 75
Oats,	1 00
Wheat bran,	60
Wheat middlings,	75
Gluten feed,	2 00
Animal meal,	2 00
Cut clover rowen,	1 50
Cabbage,	25
Cut bone,	2 00
Gluten meal,	80
Corn meal,	85
Corn,	85

Composition of Foods (Per Cent.).

Kind.	Moisture.	Air Dry Food contains —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Whole wheat,	10.51	1.85	12.64	2.55	71.01	1.44
Whole oats,	8.06	3.21	11.96	11.64	61.48	3.65
Cut clover rowen,	9.80	7.36	17.88	22.18	39.70	3.08
Wheat middlings,	9.25	4.63	17.52	9.91	53.11	5.58
Animal meal,	5.06	39.26	37.66	1.01	5.56	11.45
Whole corn,	12.11	1.31	9.55	1.90	71.26	3.87

Kind.	Moisture.	Dry Matter contains —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Bran,	12.72	6.96	18.01	11.65	57.92	5.46
Gluten feed,	9.10	0.92	24.59	7.17	63.43	3.89
Corn meal,	13.43	1.46	11.01	1.96	81.44	4.13
Cabbage,	89.45	7.94	25.69	9.31	54.76	2.30
Cut bone,	26.29	21.50	20.62	–	–	31.38
Gluten meal,	8.77	1.50	37.64	3.87	54.59	2.40

1. Effect of Condition Powder upon Egg-production.

Each coop contained twenty pullets at the beginning of the experiment; the fowls in the no condition-powder coop weighing 103 pounds, and having laid, November 18 to December 12, 46 eggs; the fowls in the condition-powder coop weighing 97 pounds, and having laid 14 eggs. The rations of the two lots of fowls were the same, except to the morning mash of one lot was added condition powder to the full amount recommended by makers; viz., 3 scoops (provided for measuring) heaping full. This amount of condition powder was enough to make the mash several shades darker than the one without it, and to impart a strong odor. Being mixed sometimes in the room where milk was standing, it imparted a flavor to butter made therefrom which was recognized by our expert butter maker, who knew nothing concerning its use, and who worked in rooms a quarter of a mile distant, to which the milk was taken. The pen receiving the powder consumed during the winter four two-pound cans of it, costing at retail $4.

Both lots of fowls were healthy throughout the entire test. Two fowls were stolen from the lot receiving no condition powders on the night of March 27. One soft-shelled egg was laid by a fowl receiving condition powder. The tables give all details necessary to a comparison of the results: —

Foods consumed, Condition-powder Experiment.

Kinds of Food.	Amount. Condition Powder. Lbs.	oz.	No Condition Powder. Lbs.	oz.
Wheat,	269	0	250	0
Oats,	155	0	152	0
Bran,	44	0	44	8
Middlings	44	0	44	8
Gluten feed,	44	0	44	8
Animal meal,	52	0	52	8
Clover,	43	0	44	8
Cabbage,	15	15	15	3

Average Weights of the Fowls (Pounds).

Dates.	Condition Powder.	No Condition Powder.
December 12,	4.85	5.15
January 31,	5.21	5.41
February 25,	5.44	5.53
March 30,	5.25	5.48
April 30,	5.11	4.88

Eggs per Month (Number).

Months.	Condition Powder.	No Condition Powder.
December,	28	59
January,	90	66
February,	86	101
March,	217	288
April,	298	291
Totals,	719	745

Condition Powder for Egg-production (December 12 to April 30).

	Condition Powder.	No Condition Powder.
Hen days,	2,751	2,656
Gross cost of food,	$8 91	$8 59
Cost per hen day,	$0 0032	$0 0032
Total number of eggs,	719	745
Cost per egg, not including powder,	$0 0124	$0 0115
Cost per egg, including powder,	$0 0180	$0 0115
Eggs per hen day,	.26+	.28+
Total weight of eggs (pounds),	88.08	90.80
Average weight of eggs (ounces),	1.96	1.95
Dry matter to produce 1 egg (pounds),	.82	.77
Dry matter consumed per hen day (pounds),	.22−	.22−
Nutritive ratio,	1:4.6+	1:4.6−
Sitters,	8	14

Eggs from both lots of fowls were tested under numbers by two families. One family reports no difference; the other found the eggs from the hens not getting the powder "much preferable" to the others.

Conclusion.

A study of the figures showing results shows that the hens not getting the condition powder laid more eggs, of practically the same average weight. The food required to produce a single egg was less, and the cost was very materially less. The average weight of the fowls not getting the powder at the close of the experiment was about one-quarter of a pound less than that of the other.

We have now carried through three experiments to test the value of condition powder for egg-production. The differences have in every case been small. In favor of the condition powder we have one experiment, against it we have two experiments. It is not, however, my disposition to claim that the powder is injurious, but simply *that it is not beneficial.* This the four experiments, carried out with the utmost fairness and with every care, certainly prove. *In the light of these results, it is believed that poultry keepers throw away money expended for condition powder.*

2. *Animal Meal v. Cut Bone for Egg-production (December 12 to April 30).*

In this experiment there were nineteen pullets in each house when the experiment began. Those in the animal-meal house weighed 101.5 pounds, and had laid, November 8 to December 12, 82 eggs. The pullets in the cut-bone coop weighed 101.25 pounds, and had laid 41 eggs.

In the morning mash of one lot one part animal meal to five parts total dry materials was used; in the mash of the other lot, the same proportion of fresh-cut bone was mixed. The large, flat bones, comparatively free from meat or fat, were used.

In the animal-meal coop the health of the birds was good, but one fowl being out of condition in any way. She be-

came sick about April 1, and was killed, as she seemed to be growing gradually worse, on April 10. The nature of the trouble was unknown. Almost from the first, bowel troubles were not uncommon in the cut-bone coop. Two fowls died (December 23 and January 11) after short illness. On April 11 one hen was found with a disjointed leg, and she was killed. The animal-meal coop laid three soft-shelled eggs; the other, two.

The bone fed amounted to only .27 ounce per hen daily. One-half ounce and over is the usual recommendation by writers upon the subject. We find it impossible to feed so largely without serious bowel trouble.

Foods consumed, Animal Meal v. Cut Bone.

Kinds of Food.	Animal Meal.		Cut Bone.	
	lbs.	oz.	lbs.	oz.
Wheat,	256	0	262	0
Oats,	143	0	145	0
Bran,	44	8	39	0
Wheat middlings,	44	8	39	0
Gluten feed,	44	8	-	
Gluten meal,	-		39	0
Animal meal,	44	8	-	
Cut bone,	-		40	0
Clover rowen,	44	8	39	0
Cabbage,	19	3	18	8

Average Weights of the Fowls (Pounds).

Dates.	Animal Meal.	Cut Bone.
December 12,	5.34	5.38
January 31,	5.64	5.66
February 25,	5.66	5.88
March 30,	5.09	5.27
April 30,	5.06	5.53

Eggs per Month (Number).

Months.	Animal Meal.	Cut Bone.
December,	63	57
January,	92	83
February,	184	120
March,	263	259
April,	210	209
Totals,	812	728

Animal Meal v. Cut Bone for Egg-production.

	Animal Meal.	Cut Bone.
Total number of eggs,	812	728
Hen days,	2,561	2,331
Gross cost of foods,	\$8 45	\$8 29
Cost per egg,	\$0 0104	\$0 0114
Cost per hen day,	\$0 0033	\$0 0035
Total weight of eggs (pounds),	100.5	88.7
Average weight per egg (ounces),	1.98	1.95
Eggs per hen day,	.32	.31
Dry matter consumed per hen day (pounds),	.22	.23
Dry matter to produce 1 egg (pounds),	.695	.739
Nutritive ratio,	1:4.6	1:4.7
Sitters,	22	13

A test of the eggs both raw and boiled was made by an expert, who found the animal-meal eggs inferior, in color and flavor, to the others.

Conclusion.

In conclusion, then, I may quote the closing summary of results made in my report upon a similar experiment last year. "The advantage in this trial lies, then, clearly with the animal meal as a food for egg-production. It has given more eggs of greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer." In one respect only is the animal meal apparently inferior to the bone this

year, viz., the fowls getting it weigh less at the close of the experiment than the others. This loss in weight is, however, far more than covered by the greater value of eggs produced.

We have now carried through five experiments, comparing these two feeds. Two have given results slightly favorable to the bone in number of eggs; one a similar result in favor of the animal meal; and two — the two last, which have been the most perfectly carried out — have been most decisively favorable to the animal meal. The latter has also been found the safer food. *The greatly preponderating weight of the evidence afforded by these experiments, which have been most carefully conducted, is, therefore, in favor of the animal meal.*

3. Narrow v. Wide Ration for Egg-production.

The experiments coming under this head have been two, one extending from December 12 to April 30, the other from May 1 to October 4. The object in view was to test the correctness of the generally held opinion that the food of the laying hen must be very rich in nitrogenous constituents. As we have carried out the experiment, it amounts to a substitution of corn meal for wheat middlings and gluten feed in the morning mash, and the replacement of about one-half of the oats and the wheat fed at night with the corn. The proportions of cut clover and of animal meal have remained the same in the two rations.

The health of the fowls on both rations has been uniformly good throughout both the winter and summer test, with a single exception, — the loss of one fowl from the effects of indigestion, — on the wide ration. It was found to require the exercise of more judgment in feeding to keep the fowls on the heavier corn ration in perfect condition. They were more easily overfed, and on two or three occasions lost appetite for their feed for short periods.

The Winter Experiment.

On December 12 the pullets, 19 in each lot, weighed as follows: narrow ration, 101.75 pounds; wide ration, 102.5

pounds. The first lot had laid, November 12 to December 12, 127 eggs; the other lot, 85 eggs, and one in this lot was broody. The foods consumed during the winter experiment and other details are shown in the following table: —

Foods consumed, Narrow v. Wide Ration (December 12 to April 30).

Kinds of Food.	Narrow Ration. lbs.	Narrow Ration. oz.	Wide Ration. lbs.	Wide Ration. oz.
Wheat,	257	0	126	0
Oats,	147	0	63	0
Bran,	43	0	39	0
Middlings,	43	0	–	
Gluten feed,	43	0	–	
Animal meal,	43	0	39	0
Clover,	44	0	39	0
Corn meal,	–		108	0
Corn,	–		136	0
Cabbage,	18	5	16	5

Average Weight of the Fowls (Pounds).

Dates.	Narrow Ration.	Wide Ration.
December 12,	5.36	5.39
January 31,	5.41	5.84
February 25,	5.45	5.80
March 30,	5.16	5.57
April 30,	5.17	5.31

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

Months.	Narrow Ration.	Wide Ration.
December 12 to 31,	94	89
January,	99	148
February,	147	258
March,	310	317
April,	210	259
Totals,	860	1,071

Narrow v. Wide Ration for Egg-production, Winter Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,529	2,538
Gross cost of foods,	$8 54	$6 56
Cost per hen day,	$0 0033	$0 0026
Total number of eggs,	860	1,071
Cost per egg,	$0 0099	$0 0061
Eggs per hen day,	.34—	.42+
Total weight of eggs (pounds),	102.425	130.53—
Average weight of eggs (ounces),	1.98	1.95
Dry matter to produce one egg (pounds),	.655	.46
Dry matter consumed per hen day (pounds),	.22	.19
Nutritive ratio,	1:4.7—	1:5.6—
Number of sitters,	30	24

Summer Experiment.

The summer experiment was continued with the same fowls that had been used in the winter. The method of feeding remained the same, save in two particulars: (1) in place of cut clover rowen in the mash every morning, lawn clippings in such quantity as the fowls would eat before wilting were fed three times per week, to each lot the same; and (2) the feeding of cabbages was discontinued. The yards (fifty by twenty-four feet) were kept fresh by frequent use of the cultivator. The health of one fowl only suffered during the experiment. One of the corn-fed fowls appeared dumpy for a few days, but was fully recovered in two weeks. As in the winter test, the fowls fed largely on corn showed less relish for their whole grain than the others. Food consumed and other details are shown below: —

Foods consumed, Narrow v. Wide Ration (May 1 to October 4).

Kinds of Food.	Narrow Ration.	Wide Ration.
	Lbs.	Lbs.
Wheat,	276	131½
Oats,	97	43
Bran,	43	40
Middlings,	43	–
Animal meal,	43	40
Corn meal,	–	106½
Corn,	–	217½
Gluten feed,	43	16

Average Weight of the Fowls (Pounds).

Dates.	Narrow Ration.	Wide Ration.
April 30,	5.17	5.31
June 11,	5.00	5.25
July 16,	5.47	5.22
August 11,	5.05	5.50
Before killing,	5.07	5.44
Dressed,	4.37*	4.81†

* Or 86 per cent. † Or 88 per cent.

Eggs per Month (Number).

Months.	Narrow Ration.	Wide Ration.
May,	216	292
June,	182	204
July,	157	210
August,	151	197
September,	139	174
October 1-14,	14	18
Totals,	859	1,095

Narrow v. Wide Ration for Egg-production, Summer Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,355	2,512
Gross cost,	$7 56	$6 64
Cost per hen day,	$0 0032	$0 0026
Total number of eggs,	859	1,095
Cost per egg,	$0 0088	$0 0061
Eggs per hen day,	.36	.44
Total weight of eggs (pounds),	106.3	130
Average weight of eggs (ounces),	1.98	1.90
Dry matter to produce one egg (pounds),	.57+	.48+
Dry matter consumed per hen day (pounds),	.21—	.21+
Sitters,	67	60

The fowls on the wide (corn) ration laid three soft-shelled eggs during the winter test and one during the summer. These are not included in the tabular reports.

Study of the results reveals the following facts: —

1. *The hens on the wide (rich in corn) ration laid a great many more eggs in both the winter and in the summer experiments than those on the narrower ration.*

2. *The difference in favor of the wide ration amounts to 25 per cent. in the winter trial and to $33\frac{1}{3}$ per cent. in the summer trial, upon the basis of equal number of hen days.*

3. *The total cost of feeds was less for the wide ration, and of course the cost per egg was much less. In the production of one hundred dozen eggs the saving on the basis of our winter test would amount to $4.56; on the basis of the summer test, to $3.24.*

4. *In average weight of the eggs produced there is a small difference in favor of the narrow ration; but in quality the weight of family evidence shows the eggs produced by the corn-fed hens to have been somewhat superior. They were deeper yellow and of a milder flavor than the eggs from the narrower ration.*

5. *The fowls on the wide ration gained somewhat in weight and were heavier at the close of the experiment than the others, notwithstanding the much larger number of eggs laid.*

At the close of the experiment the fowls were closely judged as to the condition of the plumage while still living, and it was decided that the corn-fed hens were farther advanced in moulting than the others. The fowls were slaughtered, and the judgment of the men removing the feathers coincided with the judgment on the living fowls.

The averages before and after dressing were as follows: narrow-ration fowls, 5.07 pounds; dressed weight, 4.37 pounds; wide-ration fowls, 5.44 pounds; dressed weight, 4.81 pounds. The narrow-ration fowls gave 86 per cent. dressed weight; the others, 88 per cent. The dressed fowls were judged by a market expert, who pronounced the corn-fed fowls slightly superior to the others.

The results are thus greatly in favor of the ration richer in

corn meal and corn; and so important will a knowledge of this fact prove (if confirmed by further trials), because of the cheapness of these foods as compared with wheat, that the experiment is being repeated this year with three different breeds of fowls, using corn yet more largely than last year.

4. *Influence of the Cock on Egg-production.*

At the close of the winter tests the hens that had been used in the condition-powder and cut-bone experiments were matched in such a manner as to equalize previous feed conditions in four coops of sixteen fowls each. The fowls were all put upon the same feed, and egg records were kept for two weeks, to determine whether the fowls seemed evenly matched. At the end of the time a vigorous White Leghorn cock was placed in two of the coops. We had thus two experiments co-incidently running. These will be designated respectively test No. 1 and test No. 2.

Test No. 1. Influence of the Cock on Egg-production. — In the preliminary trial the hens in pen 1 laid 129 eggs; those in pen 2, 107 eggs. In the first pen five hens were brooding; in the second, seven. The fowls in both pens were fed alike, each receiving, in addition to the feed recorded, lawn clippings three times per week. The experiment began May 13 and extended to September 2. In calculating the food cost per hen day the cock is included in the hen days, but in calculating the number of eggs per hen day the cock is not included. No ill health or accidents of any kind occurred. The cock in the trial was in pen 1.

Foods consumed (May 14 to September 2).

Kinds of Food.	Pen 1.	Pen 2.
	Lbs.	Lbs.
Wheat,	194	194
Oats,	82	78
Bran,	32	32
Middlings,	32	32
Gluten feed,	32	32
Animal meal,	32	32

Average Weight of Fowls (Pounds).

Dates.		Pen 1.	Pen 2.
May	14, beginning,	5.12	5.09
June	11,	4.69	4.91
July	16,	4.91	4.94
August	11,	4.87	5.09
September	1, end,	4.82	4.95

Influence of Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days, including cock,	1,904	-
Hen days, without cock,	1,792	1,792
Gross cost of food,	$5 53	$5 49
Cost per hen day,	$0 0029	$0 0031
Total number of eggs,	631	630
Cost per egg,	$0 0088	$0 0087
Eggs per hen day,	.35+	.36—
Total weight of eggs (pounds),	77.3	76.79
Average weight of eggs (ounces),	1.96	1.95
Dry matter consumed per hen day (pounds),	.19	.20
Dry matter consumed per egg (pounds),	.58—	.57+
Nutritive ratio,	1:4.7—	1:4.7
Sitters,	41	45

Test No. 2. Influence of the Cock on Egg-production. — During the preliminary period the fowls in pen 5 laid 90 eggs, three offering to sit; those in pen 6 laid 107 eggs, five offering to sit. The cock was placed in pen 6. One hen in pen 6 was lame from July 6 to the end of the test; one in pen 5 was injured in the back on July 22, and died August 4. This test closed August 25.

Foods consumed (May 14 to August 25).

KINDS OF FOOD.	Pen 6.	Pen 5.
	Lbs.	Lbs.
Wheat,	179	161½
Oats,	80¾	81¾
Bran,	31½	30¼
Middlings,	31½	30¼
Gluten feed,	31½	30¼
Animal meal,	31½	30¼

Average Weight of Hens (Pounds).

DATES.	Pen 6.	Pen 5.
May 14,	4.91	5.06
June 11,	4.79	4.94
July 16,	4.91	5.09
August 11,	4.94	5.17
August 23,	4.72	5.02

Influence of the Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days,	1,664	1,643
Hen days with cock,	1,768	–
Gross cost of foods,	$5 24	$4 89
Cost per hen day,	$0 0030	$0 0030
Total number of eggs,	629	526
Cost per egg,	$0 0083	$0 0093
Eggs per hen day,	.38+	.33–
Total weight of eggs (pounds),	77.84	64.76
Average weight of eggs (ounces),	1.98	1.97
Dry matter to produce 1 egg (pounds),	.55	.63–
Dry matter consumed per hen day (pounds),	.20	.20
Nutritive ratio,	1:4.8	1:4.7
Sitters,	35	33

Study of these results shows that the cock was without apparent influence upon the egg product of these fowls. The differences are very small, too insignificant to have much weight, even if in both trials of the same nature. When we note, however, that in one trial the balance was very slightly in favor of the set of fowls with which the cock was kept, and that in the other trial it was with the fowls kept without the cock, we must conclude that the results prove neither benefit nor injury due to the presence of the male. In one respect only is there agreement in the results of the two trials; the average weight of the eggs from the hens with which a male was kept was slightly the greater in both trials. It seems not impossible that this effect may be due to the fact that the eggs had been fertilized. The difference is, however, exceedingly small, and would be wholly without significance to the producer of eggs for market or for table use.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

The work of the past season has been along the lines indicated in a previous report, so far as time and circumstances would permit. It has seemed desirable to give especial attention to the immediate needs of the citizens of this Commonwealth, as indicated by the extensive correspondence, from which one is enabled to gain a pretty clear idea of the insects especially troublesome, and upon which help is needed, from year to year. The work on the gypsy and brown-tail moths has demanded a large amount of time, not only in frequent inspections of the field work in the infested territory, but also in planning and directing the scientific part of the work.

A monograph of the plume-moths (*Pterophoridæ*) of North America was prepared and published in the last college report, and a revised edition was issued in July as a special bulletin from this station. Such monographs are absolutely essential as foundation work in economic entomology. I am now at work, when other duties permit, on a similar monograph of the two remaining families of the *Pyralidæ*. Mr. Cooley's monograph on the genus *Chionaspis*, a group of very pernicious scale insects, is now quite far advanced, and will soon be ready for publication.

The San José Scale.

This insect has now unfortunately become established in various parts of the State, and has been sent here for determination during the past season more frequently than any other. This pest, as well as several other injurious scale

insects, has been brought into the State and distributed among our fruit growers on nursery stock; and, unless present in large numbers, they are liable to be entirely overlooked, both by the nurseryman and the purchaser, but when they are discovered, not only does the purchaser suffer from the loss of his trees, but the nurseryman is sure to lose his trade. As a result, some of our more progressive dealers in nursery stock, by my advice, have built fumigating houses, and treat all stock received and sent out, with hydro-cyanic acid gas.

Many of the other States have enacted laws for the regular examination of their nurseries, and also prohibiting the introduction of nursery stock that has not been examined by an expert entomologist, appointed for that purpose by the State from which the stock was shipped, and accompanied by his certificate of examination. This has shut out the trade of our nurserymen more or less from all those States where such laws exist, and, at the same time, leaves Massachusetts as a dumping ground for the infested nursery stock of other States. It is evident, therefore, that we need some law to protect us against the introduction of the San José scale and other injurious insects.

The Grass Thrips.

The amount of damage to grass done by this insect has been estimated at more than that of all others combined. This may be an overestimate, but there is no doubt that it is one of the most destructive grass insects in this Commonwealth. Very little has been known of it, beyond the fact that it is very injurious; but no method of dealing with it has been suggested that promised any great degree of success. One of my assistants has worked out its life history and bred it through all of its stages, and will prepare a bulletin on it soon.

The Small Clover-leaf Beetle.

This insect (*Phytonomus nigrirostris*) is very common on the college farm, and is quite destructive to the clover on which it feeds. Its habits and life history will be published

when the investigations now being made on it are completed. An allied species, the clover-leaf beetle (*Phytonomus punctatus*), is reported in various parts of this country, and is said to have done a great deal of damage.

The Buffalo Carpet Beetle.

The Buffalo carpet beetle has caused housekeepers more or less trouble for a long time, and the correspondence about this insect has been more extensive during the last ten years than on almost any other. My attention has recently been called to an invasion of this insect in the storehouse of the Geo. Gilbert Manufacturing Company, in Ware, where it was destroying woolen goods. After considering the matter very fully, the owners were advised to close the house as tightly as possible, and fumigate it with hydro-cyanic acid gas. Full instructions were given, in order that no accidents might occur from the use of this deadly gas.

Arsenate of Lead and Bordeaux Mixture.

Arsenate of lead has proved so valuable an insecticide for the destruction of the gypsy moth, as well as other insects, that several correspondents have inquired if it could be used with Bordeaux mixture. A trial was therefore made on several apple trees on my own grounds, with most excellent results and without any injury to the foliage, though the arsenate of lead was used in the proportion of five pounds to one hundred and fifty gallons of water. The fruit of these trees had been badly affected by the scab for several years, but after a single spraying with the above preparation the fruit in the fall was in excellent condition. Experiments will be performed with these substances another year, before giving a detailed account of the work.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, SAMUEL W. WILEY.

Part I. — Report on Official Inspection of Commercial Fertilizers.
Part II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1898.

CHARLES A. GOESSMANN.

The number of licensed manufacturers and dealers in commercial fertilizers and agricultural chemicals during the past year is sixty-one. Thirty-five of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, four in Connecticut, three in Vermont, three in Rhode Island, one in Maine, one in New Jersey, one in Illinois and two in Canada.

The distinct brands of fertilizer, including chemicals, licensed in the State, are two hundred and sixty-four.

Three hundred and seventy-eight samples of fertilizers have thus far been collected in the general market by experienced delegates of the station; of these, three hundred and sixty-three samples were analyzed at the close of November, 1898, representing two hundred and sixty-four distinct brands. The results of these analyses were published for distribution in three bulletins, Nos. 51, 54 and 57, of the Hatch Experiment Station of the Massachusetts Agricultural College, during the months of February, July and November, 1898.

The remaining samples and others coming into our hands before the expiration of the license, May 1, 1899, will be analyzed in due time, and the results published in conformity with our State laws for the regulation of the trade in commercial fertilizers.

The modes of chemical analysis adopted in our examination of fertilizers are, in all essential points, those recommended by the Association of Official Chemists.

For a better understanding and due appreciation of the trade in commercial fertilizers during the past year, the following abstract of our results is here inserted. To arrive at a correct conclusion, it must be borne in mind that only the lowest stated guarantee is legally binding on all sales: —

	1897.	1898.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	3	5
Number with two elements above the highest guarantee,	2	17
Number with one element above the highest guarantee,	60	77
Number with three elements between the lowest and highest guarantee,	69	85
Number with two elements between the lowest and highest guarantee,	63	93
Number with one element between the lowest and highest guarantee,	16	54
Number with two elements below the lowest guarantee,	6	19
Number with one element below the lowest guarantee,	29	90
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	3	5
Number with one element above the highest guarantee,	10	24

	1897.	1898.
Number with two elements between lowest and highest guarantee,	13	25
Number with one element between lowest and highest guarantee,	12	17
Number with two elements below the lowest guarantee,	3	2
Number with one element below the lowest guarantee,	6	8
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	10	18
Number between lowest and highest guarantee,	13	23
Number below the lowest guarantee,	1	15

A comparison of the above-stated results of our inspection during the years 1897 and 1898 shows no material differences regarding the general character of the fertilizers sold in our market. In a few cases it became our duty to communicate with the manufacturers, and ask for an explanation. Imperfect mixing proved in most of these cases the cause of differences between guarantee and our analysis. As the commercial value of the brand was not materially affected, with only two or three exceptions, the cases were passed over, after a satisfactory explanation from the party interested.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the successful raising of farm and garden crops congenial to climate and soil. The fact that the most important essential articles of plant food, as nitrogen, potash and phosphoric acid, are freely offered for sale in our markets in forms suitable to change the manurial refuse of the farm as stable manure and vegetable compost into complete manures for the crops to be raised, deserves the most serious attention of farmers. *To render the stated waste products of the farm in a higher degree efficacious as a manure supply cannot be otherwise considered than as a most promising step in the direction of an economical supply of plant food for the production of farm and garden crops.*

As the manufacturer at best can only prepare his special or so-called complete fertilizers on general lines, not knowing the particular character and condition of the soil which receives them, it becomes the business of the farmer to make

his selection with due care. An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

As the physical conditions and chemical resources of soils in available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised in preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station, at Amherst, Mass.

In making choice from among the so-called complete fertilizers, two points in particular seem to be worth remembering. *First*, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to the cost per ton; *mere trade names are no guarantee of fitness.* High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. *Second*, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

Valuation of Commercial Fertilizers.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of

the three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.	Ammoniate.
Nitrate of soda.	Castor pomace.
Muriate of potash.	Linseed meal.
Sulphate of potash.	Dried blood.
Cotton-seed meal.	Dried ground meat.
Dry ground fish.	Bone and tankage.
Azotin.	Plain superphosphates, etc.

which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in the form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897 and 1898: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 and 1898 (Cents per Pound).

	1897.	1898.
Nitrogen in ammonia salts,	13.5	14.0
Nitrogen in nitrates,	14.0	13.0
Organic nitrogen in dry and fine ground fish, meat blood, and in high-grade mixed fertilizers,	14.0	14.0
Organic nitrogen in cotton-seed meal,	12.0	12.0
Organic nitrogen in fine bone and tankage,	13.5	13.5
Organic nitrogen in medium bone and tankage,	11.0	10.0
Phosphoric acid soluble in water,	5.5	4.5
Phosphoric acid soluble in ammonium citrate,	5.0	4.0
Phosphoric acid in fine bone and tankage,	5.0	4.0
Phosphoric acid in cotton-seed meal, castor pomace, wood ashes and fine-ground fish,	5.0	4.0
Phosphoric acid in coarse bone and tankage,	2.5	3.5
Phosphoric acid insoluble (in ammonium citrate) in mixed fertilizers,	2.0	2.0
Potash as sulphate (free from chlorides),	5.0	5.0
Potash as muriate,	4.5	4.25

From these figures it is apparent that some of the best forms of nitrogen and phosphoric acid have suffered, as a rule, a reduction in cost, as compared with preceding years.

For further details I have to refer to preceding annual reports.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties.

The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home composition, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1898, to May 1, 1899), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Butchers' Rendering Association, Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

H. J. Baker & Bro., New York, N.Y.: —
- Standard Un X Ld Fertilizer.
- Strawberry Manure.
- Potato Manure.
- Complete Cabbage Manure.
- A. A. Ammoniated Superphosphate.
- Complete Manure for General Use.
- Grass and Lawn Dressing.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport Conn.: —
- Complete Fertilizer.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash, ⟨H⟩ B.
- Fish Scrap No. 2, ⟨H⟩ B.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Hill and Drill Phosphate.
- Farm and Garden Phosphate.
- Lawn and Garden Dressing.
- Fish and Potash.
- Potato and Vegetable Manure.
- Potato Phosphate.
- Market Garden Manure.
- Sure Crop Phosphate.
- Gloucester Fish and Potash.
- High-grade Fertilizer.
- Essex Fertilizer.
- Bone and Wood Ash Fertilizer.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.

William E. Brightman, Tiverton, R. I.: —
- Potato and Root Manure.
- Phosphate.
- Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- X. L. Superphosphate.
- Potato Manure.
- B. D. Sea Fowl Guano.
- Complete Manures.
- Fish and Potash.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.
- Corn Phosphate.
- Muriate of Potash.
- Nitrate of Soda.
- Dissolved Bone.
- Fine-ground Bone.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's B Special.
- Church's C Standard.
- Church's D Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer G. G. Brand.

Clark's Cove Fertilizer Co. — *Con.*
Great Planet Manure.
Potato Fertilizer.
King Philip Guano.
Potato Manure.
Fish and Potash.
White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass.: —
Superphosphate.
Potato Phosphate.
Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
High-grade Potato Fertilizer.
Tobacco and Onion Fertilizer.
High-grade Ammoniated Bone Superphosphate.
Gold Brand Excelsior Guano.
Fish Guano and Potash.
Bay State Phosphate.
Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
Ammoniated Bone Superphosphate.
Potato, Hop and Tobacco Phosphate.
Ammoniated Wheat and Corn Phosphate.
New Rival Ammoniated Superphosphate.
Vegetable Bone Superphosphate.
General Crop Phosphate.
Universal Grain Grower.
Special Potato Manure.
New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Superphosphate.
Potato Fertilizer.
Concentrated Phosphate.
Fertilizer.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
Animal Fertilizer.
Potato and Root Crop Manure.
Tobacco Grower.
Blood, Bone and Potash.
Special Formula.
Fine-ground Bone.
Muriate of Potash.
Nitrate of Soda.
Farm Favorite.

John C. Dow & Co., Boston, Mass.: —
Nitrogenous Superphosphate.
Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Liquid Plant Food.

W. E. Fyfe & Co., Clinton, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Northern Corn Special.
General Fertilizer.
Vegetable, Vine and Tobacco Fertilizer.
Garden Special.
Grass and Oats Fertilizer.

Thomas Hersom & Co., New Bedford, Mass.: —
Bone Meal.
Meat and Bone.

Edmund Hersey, Hingham, Mass.: —
Ground Bone.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Celebrated Onion Fertilizer.
Lister's Success Fertilizer.
Lister's Special Potato Fertilizer.
Lister's Special Tobacco Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
Bone Fertilizer for Corn and Grain.
Animal Fertilizer.
Potato Phosphate.
Bone and Potash.
Lawn Dressing.
Tobacco Manure.
Fruit and Vine Fertilizer.
Market-garden Fertilizer.
Ground Bone.

Lowe Bros., & Co., Fitchburg, Mass.: —
Tankage.

F. R. Lalor, Dunville, Ontario, Can.: —
Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Bone Manures.
- Superphosphates.
- Special Crop Manures.
- Sulphate of Potash.
- Double Manure Salts.
- Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can.: —
- Unleached Hard-wood Ashes.

McQuade Bros., West Auburn, Mass.: —
- Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y.: —
- Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
- Complete Fertilizers.
- Ammoniated Bone.
- Market-garden Manure.
- Potato Phosphate.
- Fish and Potash.
- Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
- Wheat and Corn Producer.
- Potato, Tobacco and Hop Fertilizer.
- Niagara Triumph.

Packers Union Fertilizer Co., New York, N. Y.: —
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Animal Corn Fertilizer.
- Potato Manure.
- Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass.: —
- Soluble Pacific Guano.
- Special Potato Manure.
- Nobsque Guano.
- High-grade General Fertilizer.
- Grass and Grain Fertilizer.
- Fish and Potash.
- Pacific Guano with 10 per cent. Potash.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Star Brand Superphosphate.

Parmenter & Polsey Fertilizer Co. — Con.
- Special Potato.
- Strawberry and Small Fruits.
- Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- P. & P. Potato Fertilizer.

A. W. Perkins & Co., Rutland, Vt.: —
- Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
- Pioneer.
- Potato Fertilizer.
- Superphosphate, I.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Market-garden Manure.
- Fish and Potash.
- Grass Fertilizer.
- Corn Manure.
- Potato Phosphate.
- Climax Phosphate.
- Pure Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- Kainit.
- Dissolved Bone-black.

Benjamin Randall, East Boston, Mass.: —
- Market-garden Fertilizer.
- Farm and Field.
- Ground Raw Bone.

Read Fertilizer Co., New York, N. Y. (H. D. Foster, general agent): —
- Standard Fertilizer.
- High-grade Farmers' Friend.
- Practical Potato Special.
- Vegetable and Vine.
- Fish, Bone and Potash.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

The Rogers & Hubbard Co., Middletown, Conn.: —
Hubbard's Soluble Potato Manure.
Hubbard's Soluble Tobacco Manure.
Hubbard's Fairchild's Formula for Corn and General Crops.
Hubbard's Grass and Grain Fertilizer.
Hubbard's Oats and Top-dressing Fertilizer.
Hubbard's Pure Raw Knuckle Bone Flour.
Hubbard's Strictly Pure Fine Bone.
Hubbard's Fertilizer for all Soils and all Crops.

Russia Cement Co., Gloucester, Mass.:—
X X X Fish and Potash.
High-grade Superphosphate.
Corn, Grain and Grass Manure.
Potato, Root and Vegetable Manure.
Odorless Lawn Dressing.
Potato Fertilizer.
Dry Ground Fish.
Special Manure for Carnations.

Lucien Sanderson, New Haven, Conn.:—
Formula A.
Blood, Bone and Meat.
Dissolved Bone-black.
Nitrate of Soda.
Sulphate of Potash.
Muriate of Potash.
Sanderson's Old Reliable Superphosphate.
Sanderson's Potato Manure.

Edward H. Smith, Northborough, Mass.: —
Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
Ground Bone.

Standard Fertilizer Co., Boston, Mass.:—
Standard Fertilizer.
Standard Guano.
Complete Manure.
Special for Potatoes.

C. F. Sturtevant, Hartford, Conn.: —
Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.
Bay State Special.

Andrew H. Ward, Boston, Mass.: —
Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
Complete Manure.

D. Whithead, Lowell, Mass.: —
Champion Garden Fertilizer.
Bone Meal.

The Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Tobacco Manure.
High-grade fish and potash.
Dry Ground Fish Guano.
Fish and Potash 1895 Brand.

Williams and Clark Fertilizer Co., Boston, Mass.: —
Ammoniated Bone Superphosphate.
Potato Phosphate.
High-grade Special.
Fine Wrapper Tobacco Grower.
Royal Bone Phosphate.
Corn Phosphate.
Potato Manure.
Grass Manure.
Fish and Potash.
Prolific Crop Producer.
Onion Manure.
Bone Meal.
Dry Ground Fish.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
High-grade Corn Fertilizer.
High-grade Potato Manure.
Superior Truck Fertilizer.
High-grade Fruit Fertilizer.
High-grade Grass and Oats Fertilizer.

A. L. Warren, Northborough, Mass.: —
Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
Fine-ground Bone.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Wood Ashes, Condition of Trade, etc.
3. Notes on Fertilizers for Pot Cultivation and Greenhouses.
4. Observations regarding the Action of Acid and Basic Phosphates on the Availibility of the Nitrogen in Blood, Steamed Leather and Leather Scraps.
5. Notes on the Determination of the Available Phosphoric Acid in the Soil.
6. Analyses of Drainage Waters obtained in Connection with Some Field Experiments carried on upon the Grounds of the Station.

1. Analyses of Materials sent on for Examination.

The number of substances tested in this connection amount to several hundred. The results of our examination are already published in detail in Bulletins 51, 54 and 57 of the Hatch Experiment Station of the Massachusetts Agricultural College, in connection with the results of the official inspection of commercial fertilizers collected from original packages by an efficient delegate of the station.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for the analysis. Our publication of the results refers merely to the locality they come from, to avoid misunderstandings. The work carried on in this connection is growing from year to year in importance.

A large proportion of commercial manurial substances consist of by or waste products of various industries. The composition and general character of these materials depend

on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason, arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers, to the full extent of the resources placed at the disposal of the officer in charge of this work.

These investigations are carried on free of charge to farmers of the State, and as far as the financial resources of the laboratory admit. The examination of the materials is, as a rule, carried on in the order they arrive at the station, and the results are considered public property.

The following statement of the names of the different articles sent on and thus far analyzed may suffice here to convey some more definite idea concerning the general character of the work: —

Materials sent on, Dec. 1, 1897, to Dec. 1, 1898.

Air-dried potatoes,	9	Peat,	1
Acid phosphate,	2	Nitrate of soda,	3
Ashes from cremation of garbage,	1	Sulphate of ammonia,	1
Bleachery refuse,	2	Sulphate of potash and magnesia,	1
Broom corn seed,	1	Sulphate of potash,	2
Cotton-seed meal,	2	Sweet clover hay,	3
Compound fertilizers,	21	Sulphate of magnesia,	1
Cremation ashes,	1	Soya bean refuse,	1
Dissolved bone-black,	1	Starch,	2
Fodder material,	1	Sewage,	1
Ground bone,	9	Soil,	12
Ground fish,	1	Silicate of potash,	1
Hop refuse,	1	Tankage,	3
Lime-kiln ashes,	2	Tobacco stems,	1
Liquid fertilizer,	1	Tobacco refuse,	1
Manure,	12	Teopik fibre,	1
Marl,	1	Wood ashes,	79
Muriate of potash,	3	Wool waste,	1
Muck,	5	Whale-bone scrapings,	1
Minerals,	3	Vat deposit,	1
Oxalic acid,	1		

A few of the more important of the above-stated materials, as wood ashes, etc., are discussed more at length in subsequent pages.

2. Notes on Wood Ashes.

Wood ashes for manurial purposes are in our State subject to official inspection, and dealers in that commodity have to secure a license to sell in our State before they can legally advertise their articles for sale. This circumstance makes it obligatory on the dealers to state the amount of potash and of phosphoric acid they guarantee in these materials, and to fasten that statement upon the package or car, etc., which contains them.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered, in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both, as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid. Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and the general character of foreign matters are apt to seriously affect the weight of a given measure.

During the past year (1898) 40.1 per cent. of the materials sent on for analysis consisted of wood-ash samples; during the preceding year (1897) they amounted to 40 per cent.

The general character of the wood ashes sold during the stated years may be judged from the following classified statement of our results: —

		No. of Samples. 1897.	1898.
Moisture from 1 to 3 per cent.,		10	9
Moisture from 3 to 6 per cent.,		8	6
Moisture from 6 to 10 per cent.,		13	20
Moisture from 10 to 15 per cent.,		19	22
Moisture from 15 to 20 per cent.,		11	16
Moisture from 20 to 30 per cent.,		10	6
Moisture above 35 per cent.,		1	–
Potassium oxide above 8 per cent.,		3	4
Potassium oxide from 7 to 8 per cent.,		8	6
Potassium oxide from 6 to 7 per cent.,		21	8
Potassium oxide from 5 to 6 per cent.,		28	22
Potassium oxide from 4 to 5 per cent.,		10	25
Potassium oxide from 3 to 4 per cent.,		3	11
Potassium oxide below 3 per cent.,		–	3
Phosphoric acid above 2 per cent.,		4	6
Phosphoric acid from 1 to 2 per cent.,		45	60
Phosphoric acid below 1 per cent.,		24	13
Average per cent. of calcium oxide (lime),		34.29	33.60
Per cent. mineral matter insoluble in diluted hydrochloric acid, from —	below 5,	–	1
	6 to 10,	10	16
	10 to 15,	30	31
	15 to 20,	15	15
	20 to 30,	3	13
	above 30,	1	–

As the majority of dealers in wood ashes guarantee from 4.5 to 6 per cent. of potassium oxide in their articles, it will be seen that a large number of the samples are below even the lowest guarantee; showing, on the whole, that the quality of wood ashes sold in 1898 as a potash source has been inferior, when compared with the preceding year. Whether this circumstance is due to a general decline of the article or to the management of any particular importer or dealer is difficult to decide on our part, as long as farmers do not state the name of the party from whom they have bought, or the cost per ton of the ashes they send on for examination.

It is most desirable to ascertain whether the general character of the wood ashes is gradually declining from natural causes, or whether some parties are handling inferior goods. All interested in the solution of this question will confer a favor on us by sending with their samples of wood ashes the names of the party from whom they bought the article, and

state the price per ton asked at the nearest depot for general distribution.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

3. Notes on Fertilizers suitable for raising Plants in Pots and Greenhouses.

The interest in raising plants in pots and under glass in greenhouses, by the aid of commercial fertilizers, is gradually increasing, judging from numerous applications for information.

The following analyses represent two samples of fertilizers recommended for that purpose; they were sent on for a general analysis by parties interested in the matter: —

1. Plant Food in Pellet Form, sent on from Newtonville, Mass.

	Per Cent.
Moisture,	3.39
Organic and volatile matter,	41.15
Ash constituents,	58.85
Water soluble material,	82.40
Insoluble residue (in water),	17.60
Total phosphoric acid,	16.59
Soluble phosphoric acid,	14.58
Reverted phosphoric acid,	1.67
Insoluble phosphoric acid,	.34
Potassium oxide, total,	7.96
Potassium oxide, water soluble,	7.63
Sodium oxide,	6.19
Calcium oxide,	4.04
Magnesium oxide,	5.30
Chlorine,	6.05
Sulphuric acid (SO_3),	17.17
Total nitrogen,	7.65
Nitrogen as ammoniates,	7.06
Nitrogen as nitrates,	.50
Nitrogen as organic matter,	.09
Insoluble matter in dilute hydrochloric acid (clay),	14.33

Water solution strongly acid.

2. Liquid Fertilizer sent on from Natick, Mass.

	Per Cent.
Moisture,	90.46
Solid residue,	9.54
Phosphoric acid,	1.24
Potassium oxide,	2.79
Sodium oxide,	1.67
Calcium oxide,	1.82
Magnesium oxide,	.07
Chlorine,	.02
Sulphuric acid (SO_3),	–
Total nitrogen,	1.12
Nitrogen as ammoniates,	.39
Nitrogen as nitrates,	.73
Reaction strongly acid.	

The importance of the interests involved induced the writer some years ago to enter upon a series of experiments, to assist in the development of a more efficient system of manuring several important industrial crops, fruits and garden vegetables. The first results of that investigation are published in the eleventh and twelfth reports of the director of the Massachusetts State Agricultural Experiment Station, to which I have to refer for details. Those of later years are contained in the annual report of the Hatch Experiment Station of the Massachusetts Agricultural College for 1896 and 1897.

In the course of my discussion of the lessons to be derived from the above-stated experiment in field and vegetation house, it was recommended to observe the following rules : —

1. To avoid an accumulation of half-decayed vegetable matter in the soil, and to enrich the latter in the desired direction by means of concentrated chemical manures.

2. To change, wherever practicable, from season to season the position of the various crops, to favor the destruction of parasites and to economize the inherent sources of plant food.

3. To avoid an accumulation of salines in the soil, not called for by the crops, or considered injurious to the chemical or physical properties of the soil.

4. To prevent a marked acidity of the soil, by a periodical application of air-slacked lime, wood ashes, etc.

5. To select the various commercial forms of nitrogen, and potash in particular, with special reference to the kind and the desired character of the crop to be raised.

6. To use as a general fertilizer a mixture of two parts of available potassium oxide, one part of available nitrogen and one part of available phosphoric acid, in such quantities per acre as the conditions of the soil and composition of the crop to be raised called for; allowing, for the composition of one thousand pounds of green garden vegetables, on an average: —

	Pounds.
Nitrogen,	4.01
Phosphoric acid,	1.90
Potassium oxide,	3.90

On account of the frequent cultivation of beans and peas as garden crops, a fertilizer of the following composition suggested itself to me: —

	Parts.
Available nitrogen,	1
Available potash,	2
Available phosphoric acid,	1

More recent observations confirm the advisability of the previously stated rules in a general way; yet they also emphasize the fact that, wherever the quality of the crop controls its economical and commercial value, it seems advisable that care should be taken to secure the exclusion of an accumulation of soluble saline substances not called for by the crop. This circumstance deserves particular attention in cultivation under glass, where the body of the soil is limited, and the removal of such substances by percolation to the lower layers offers but little chance of relief.

In our experiments above described this view of the question of supplying plant food in the greenhouse has aided us in selecting a series of concentrated chemical manures, which for the above reason are now recommended for patronage: —

Name of Substance.	Potassium Oxide (Per Cent.).	Phosphoric Acid (Per Cent.).	Nitrogen (Per Cent.).
High-grade muriate of potash, ...	50.00	–	–
High-grade sulphate of potash, ...	50.20	–	–
Potash-magnesia sulphate, ...	24.32	–	–
Carbonate of potash-magnesia, ...	18.48	–	–
Phosphate of potash, ...	32.56	35.70	–
Dissolved bone-black, ...	–	13.88	–
Odorless phosphate, phosphatic slag, . .	–	18.42	–
Double superphosphate, ...	–	47.80	–
Phosphate of ammonia, ...	–	43.86	10.37
Dried blood, ...	–	4.02	10.00
Nitrate of soda, ...	–	–	14.28
Sulphate of ammonia, ...	–	–	19.59

As the local conditions of the soil and the composition of the individual characteristics of the plants to be raised deserve especial attention, when selecting from the above-stated commercial manurial substances the constituents for the fertilizer mixtures to be used, it cannot be considered judicious to recommend any particular combination as being unfailing and best in all cases. For this reason it has been thought best to state in this connection, as a mere matter of illustration, a few combinations of manurial substances which served us well, as may be noticed from a few preceding annual reports, — State Experiment Station, 1893, pages 241 to 261; and 1894, pages 274 to 285.

The amount of fertilizer recommended per acre, under fair conditions of the soil, contains: —

	Pounds.
Available nitrogen, ...	60
Available phosphoric acid, ...	60
Available potash, ...	120

Some Combinations of High-grade Substances for Use in Garden, Greenhouse and Pots.

1. Nitrate of soda.
   High-grade sulphate of potash.
   Dissolved bone-black.

2. Sulphate of ammonia.
   High-grade sulphate of potash.
   Dissolved bone-black.

3. Dried blood.
   High-grade sulphate of potash.
   Dissolved bone-black.

4. Nitrate of soda.
   Muriate of potash.
   Dissolved bone-black.

Mixtures of muriate of potash and sulphate of ammonia have proved in our experience in many cases objectionable, on account of a mutual decomposition into chloride of ammonia and sulphate of potash.

4. Observations with Dried Blood and Two Kinds of Leather Refuse as the Sources of Nitrogen for growing Rye in Presence of Acid and of Alkaline Phosphates.

In a preceding report an experiment has been briefly described in which dried blood has been compared with leather refuse as a nitrogen source for growing plants, when used in connection with double phosphate and muriate of potash. The differences of the crops raised were more marked with reference to the yield of the straw than to that of the grain. (For details, see annual report of the Massachusetts State Agricultural Experiment Station for 1894, pages 283–285.) It seemed advisable to repeat the experiments, with such modifications as experience suggested, to secure, if possible, *more decisive results*, and to ascertain whether the degree of availability of the nitrogen contained in the dried blood and in the leather refuse would not be more strikingly modified by using *alkaline phosphates* instead of *acid phosphates* as the phosphoric acid source.

The following course was adopted. Winter rye was again selected for the observation. The soil used was taken from the same locality, at eighteen inches below the surface, and freed from coarse materials by repeated screening through a sand screen, as in the first experiment. The fertilizers used were in each case carefully distributed throughout the entire body of the soil. The boxes were the same which had been used in the preceding experiments, containing from seventy-five to eighty pounds of soil, having a depth of eighteen inches.

Six boxes were employed in the experiment; three served for the trial with acid phosphate, — dissolved bone-black; and three with an alkaline phosphate, — phosphatic slag meal. The following mixtures of fertilizers were used (weights are stated in grams; thirty grams equal to one ounce): —

First Lot, Nos. 1, 3 and 5.

Box 1.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Dried blood,	40.22

Box 3.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 5.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Raw-leather waste,	56.64

Second Lot, Nos. 2, 4 and 6.

Box 2.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Dried blood,	40.22

Box 4.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 6.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Raw-leather waste,	56.64

The Seed. — Winter rye was planted in all boxes Oct. 2, 1894. The young plants came up uniformly in all boxes October 5. They reached a height of from five to six inches before frost set in. After being fully developed, they were reduced in all the boxes to a corresponding number, as in the first experiment.

The watering of the soil was partly by subirrigation and partly by surface application, maintaining as far as practicable the moisture of the soil from 15 to 18 per cent. during the growing season. The experiment was conducted with a view to expose the soil to the unrestricted influence of the local temperature of the various seasons. A layer of snow served as protection to the young growth during severe spells of frost in winter.

The manurial substances used consisted of high-grade sulphate of potash, dissolved bone-black, phosphatic slag meal, dried blood, Philadelphia tankage (a steamed leather), and ground sole leather waste. The amount of nitrogen and

potassium oxide applied was the same in each case, while the amount of total phosphoric acid applied in case of the phosphatic slag meal was one-fourth more than in the case of the dissolved bone-black, which is practically all soluble in water.

Composition of the Manurial Substance used, with Reference to Potash, Phosphoric Acid and Nitrogen (Per Cent.).

	Potassium Oxide.	Phosphoric Acid.	Nitrogen.
Sulphate of potash,	50.20	-	-
Dissolved bone-black,	-	14.00	-
Phosphatic slag meal,*	-	18.40	-
Dried blood,	-	4.00	10.00
Philadelphia tankage (steamed leather),	-	-	7.80
Ground leather waste,	-	-	7.02

* Calcium oxide, 48.6 per cent.

They grew at a similar rate during spring until the latter part of April, when those which had received dried blood as nitrogen source (boxes 1 and 2) became more stalky, developing more and broader leaves than the plants in boxes 3, 4, 5 and 6. This difference in their growth became more marked as the season advanced.

The following statement gives the average height of the plants at various stages of observation (inches): —

	May 1.	May 9.	May 20.	June 1.
Box 1,	8.0	21.5	34.0	50.0
Box 3,	7.0	16.5	24.0	32.0
Box 5,	6.0	14.0	22.5	30.5
Box 2,	9.0	26.0	38.0	56.5
Box 4,	7.0	17.5	25.0	32.5
Box 6,	7.0	17.5	26.0	35.0

The plants in all boxes began blooming about the same time, the first week of June; they were harvested the first week of July. There was no marked difference in regard

to time of maturing. The general character of the matured growth will be seen from the subsequent statement of the weights of the average plant in each case (grams): —

	Box 1.	Box 3.	Box 5.	Box 2.	Box 4.	Box 6.
Moisture,	8-9	8-9	8-9	8-9	8-9	8-9
Total plant,	57.87	26.02	28.80	115.99	30.27	36.21
Kernels,	12.77	5.43	5.80	28.89	6.18	9.75
Chaff and straw,	45.12	20.69	23.00	87.10	24.09	26.46
One hundred kernels,	1.58	1.44	1.48	1.79	1.58	1.62

The plants were in all cases cut two inches above their roots. As it was of interest to know the amount of nitrogen in the kernels of the highest and lowest weights, a nitrogen determination of the kernels obtained in boxes 1 and 3, and 2 and 4 was carried out. The analyses gave the following results: —

No. of Box.	Per Cent. Nitrogen.	Fertilizing Elements Used.
1,	1.84	Dried blood, dissolved bone-black.
3,	1.91	Philadelphia tankage, dissolved bone-black.
2,	2.31	Dried blood, phosphatic slag.
4,	2.19	Philadelphia tankage, phosphatic slag.

Fodder Analyses of Rye Samples (Kernels) as far as Material on Hand sufficed for a Complete Analysis. Samples grown in Boxes 1, 2, 3 and 4 (Per Cent.).

	Box 1.	Box 2.	Box 3.	Box 4.
Moisture,	10.45	9.92	4.87	8.50
Dry matter,	89.55	90.08	95.13	91.50
	100.00	100.00	100.00	100.00

Analysis of Dry Matter.

	Box 1.	Box 2.	Box 3.	Box 4.
Fat,	2.05	2.00	2.12	1.97
Protein,	11.50	14.44	11.94	13.69
Cellulose,	1.55	1.65	1.65	1.62
Ashes,	1.95	1.52	2.20	1.44
Carbohydrates,	82.95	80.39	82.09	81.28
	100.00	100.00	100.00	100.00

Judging from the results obtained in connection with the described experiment the following conclusions suggest themselves: —

Conclusions. — The alkaline phosphate (phosphatic slag meal) has under fairly corresponding conditions increased the availability of the nitrogen contained in steamed leather, in leather scraps and in dried blood in a higher degree than the acid phosphate. The influence is apparent alike in the general character of the entire plant and in the composition of the kernels. The difference in the relative agricultural value of both articles as nitrogen sources remains, however, the same; for leather in any form, without a previous destruction of the tanning principle, tannin, is worthless for manurial purposes.

5. Contribution to the Determination of the Available Phosphoric Acid in Soils under Cultivation.

The fact that agricultural chemists have thus far failed to point out any mode of soil analysis as reliable, by which the amount of phosphoric acid available to crops can be ascertained, is pretty generally recognized. Attempts are not wanting to solve this important question. Among the well-known investigations in that direction are those of Dr. B. Deyer (1894). Results of later years obtained in this connection upon soils of well-known history at Rothamsted in England are pronounced very encouraging by Dr. Gilbert. The American Association of Official Chemists has during the past year entered upon a systematic investigation

regarding the best course to be adopted to determine the available phosphoric acid; in this work the writer has taken some part. A compilation of the contributions to these more recent experiments is to be published soon by the United States Department of Agriculture.

Our local observations at Amherst are briefly described in a few subsequent pages upon a field which had been under careful observation for five years, 1890–95. The following brief abstract of the management of the field work shows the condition of the soil which served for our investigation: —

Field F.

The field selected for this purpose is 300 feet long and 137 feet wide, running on a level from east to west. Previous to 1887 it was used as a meadow, which was well worn out at that time, yielding but a scanty crop of English hay. During the autumn of 1887 the sod was turned under and left in that state over winter. It was decided to prepare the field for special experiments with phosphoric acid by a systematic exhaustion of its inherent resources of plant food. For this reason no manurial matter of any description was applied during the years 1887, 1888 and 1889.

The soil, a fair sandy loam, was carefully prepared every year by ploughing during the fall and in the spring, to improve its mechanical condition to the full extent of existing circumstances. During the same period a crop was raised every year. These crops were selected, as far as practicable, with a view to exhaust the supply of phosphoric acid in particular. Corn, Hungarian grass and leguminous crops (cow-pea, vetch and serradella) followed each other in the order stated.

1890. — The field was subdivided into five plats, running from east to west, each twenty-one feet wide, with a space of eight feet between adjoining plats.

The manurial material applied to each of these five plats contained, in every instance, the same form and the same quantity of potassium oxide and of nitrogen, while the phosphoric acid was furnished in each case in the form of a different commercial phosphoric-acid-containing article,

namely, phosphatic slag, Mona guano, Florida phosphate, South Carolina phosphate (floats) and dissolved bone-black. The market cost of each of these articles controlled the quantity applied, for each plat received the same money value in its particular kind of phosphate.

Analyses of Phosphates used.

[I., phosphatic slag; II., Mona guano; III., Florida phosphate; IV., South Carolina phosphate; V., dissolved bone-black.]

	PER CENT.				
	I.	II.	III.	IV.	V.
Moisture,	.47	12.52	2.53	.39	15.96
Ash,	–	75.99	89.52	–	61.46
Calcium oxide,	46.47	37.49	17.89	46.76	–
Magnesium oxide,	5.05	–	–	–	–
Ferric and aluminic oxides,	14.35	–	14.25	5.78	–
Total phosphoric acid,	19.04	21.88	21.72	27.57	15.82
Soluble phosphoric acid,	–	–	–	–	12.65
Reverted phosphoric acid,	–	7.55	–	4.27	2.52
Insoluble phosphoric acid,	–	14.33	–	23.30	.65
Insoluble matter,	4.39	2.45	30.50	9.04	6.26

The following fertilizer mixtures have been applied annually to all the plats, with the exception of Plat 3, which received in 1890 ground apatite and in 1891 no phosphate whatever: —

PLATS.	Annual Supply of Manurial Substances.	Pounds.
Plat 1 (south, 6,494 square feet),	Ground phosphatic slag, Nitrate of soda, Potash-magnesia sulphate,	127 43 58
Plat 2 (6,565 square feet),	Ground Mona guano, Nitrate of soda, Potash-magnesia sulphate,	128 43½ 59
Plat 3 (6,636 square feet),	Ground Florida phosphate, Nitrate of soda, Potash-magnesia sulphate,	129 44 59
Plat 4 (6,707 square feet),	South Carolina phosphate, Nitrate of soda, Potash-magnesia sulphate,	131 44½ 60
Plat 5 (6,778 square feet),	Dissolved bone-black, Nitrate of soda, Potash-magnesia sulphate,	78 45 61

The phosphatic slag, Mona guano, South Carolina phosphate and Florida phosphate were applied at the rate of 850 pounds per acre; dissolved bone-black at the rate of 500 pounds per acre. Nitrate of soda was applied at the rate of 250 pounds per acre and potash-magnesia sulphate at the rate of 390 pounds per acre.

Potatoes were raised upon the plats in 1890; in 1891 winter wheat was employed (for details see ninth annual report); in 1892 serradella was the crop experimented with (see tenth annual report); and in 1893 a variety of Dent corn, Pride of the North (see eleventh annual report).

1894. — During the preceding season it was decided to ascertain the after-effect of the phosphoric acid applied during previous years by excluding it from the fertilizer applied. In addition, to secure the full effect of the phosphoric acid stored up, the potassium oxide and nitrogen were increased one-half, as compared with preceding seasons. A grain crop (barley) calling for a liberal amount of phosphoric acid was chosen for the trial. The field was ploughed April 17, the fertilizer being applied broadcast April 20, and harrowed in. Below is given a statement of fertilizer applied: —

Plat 1 (6,494 square feet),	64½ pounds of nitrate of soda. 87 pounds of potash-magnesia sulphate.
Plat 2 (6,565 square feet),	65¼ pounds of nitrate of soda. 88 pounds of potash-magnesia sulphate.
Plat 3 (6,636 square feet),	66 pounds of nitrate of soda. 89 pounds of potash-magnesia sulphate.
Plat 4 (6,707 square feet),	66¾ pounds of nitrate of soda. 90 pounds of potash-magnesia sulphate.
Plat 5 (6,778 square feet),	67½ pounds of nitrate of soda. 90½ pounds of potash-magnesia sulphate.

Yield of Crop (1894).

PLATS.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1,	490	169	221	34.49	65.51
Plat 2,	405	148	251	34.07	65.93
Plat 3,	290	78	212	26.89	73.11
Plat 4,	460	144	216	31.30	68.70
Plat 5,	390	118	272	30.26	69.74

Summary of Yield of Crop (1890–94).

Plats.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.	1894. Barley.
Plat 1,	1,600	380	4,070	1,660	490
Plat 2,	1,415	340	3,410	1,381	405
Plat 3,	1,500	215	2,750	1,347	290
Plat 4,	1,830	380	3,110	1,469	460
Plat 5,	2,120	405	2,920	1,322	390

Phosphoric Acid applied to and removed from Field.

[Pounds.]

Plats.	1890.		1891.		1892.		1893.		1894.		Total Amount Added.	Total Amount Removed.	Total Amount Remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1,	24.18	2.56	24.18	1.23	24.18	8.95	24.18	7.20	-*	1.92	96.72	21.86	75.86
Plat 2,	28.01	2.36	28.01	1.19	28.01	7.50	28.01	6.33	-*	1.64	72.04	19.02	53.02
Plat 3,	109.68	2.40	-*	.69	28.01	6.05	28.01	5.95	-*	.76	165.70	15.85	149.85
Plat 4,	36.12	2.93	36.12	1.31	36.12	6.84	36.12	6.68	-*	1.72	144.48	19.84	124.64
Plat 5,	12.34	3.39	12.34	1.22	12.34	6.42	12.34	6.05	-*	1.49	49.36	18.57	30.79

* None.

Conclusions.

From the previous statement of comparative yield we find that the plat receiving dissolved bone-black leads in yield during the first two years, while for the third, fourth and fifth years the plats receiving insoluble phosphates are ahead, phosphatic slag being first, South Carolina floats second and Mona guano third.

Description of Modes of Analysis adopted in our Investigations of Samples of Soil taken from the above-mentioned Five Plats in September, 1894, in the Manner recommended by the Committee of the American Association of Official Chemists, Prof. Harry Snyder of Minnesota, Chairman.

I. — Total Phosphoric Acid.

Ten grams of soil are digested with 100 c.c. of pure hydrochloric acid, of specific gravity 1.115, for ten con-

secutive hours in a boiling-water bath, shaking once each hour. The stopper of the flask should carry a condensing tube, to prevent evaporation. The material is filtered, and the residue is washed with distilled water until free of acid. The organic matter in filtrate is oxidized with nitric acid and evaporated to dryness on the water bath, finishing on sand bath to complete dryness. The material when cool is taken up with hot water and a few cubic centimeters of hydrochloric acid, and again evaporated to complete dryness. It is taken up as before, filtered and washed thoroughly with cold water, cooled and made up to 500 c.c.

II. — Directions of the Association of Official Agricultural Chemists for the Determination of Available Phosphoric Acid in Soils, Fifth Normal Hydrochloric Acid being used as the Solvent.

1. Determination of Moisture. — Use the official method described in Bulletin 46, page 48, Division of Chemistry, United States Department of Agriculture. Calculate all results to the water free basis.

2. Determination of Phosphoric Acid Soluble in Fifth Normal Hydrochloric Acid. — (*a*) Preliminary treatment: Digest 20 grams of soil with 200 c.c. of fifth normal hydrochloric acid at 40° C. for five hours. Titrate 20 c.c. of the clear filtrate against a standard caustic soda solution, using phenolphthaline for the indicator. From this data calculate the amount of hydrochloric acid necessary to be added, so that the solution will be fifth normal after allowing for the acid neutralized. (*b*) The determination: Weigh out 50 to 100 grams of soil into an Erlenmeyer flask, and add 10 c.c. of acid, corrected for neutralization as directed under (*a*) for every gram of soil used. The flask is corked with a rubber stopper, which carries a thermometer. The flask is then placed in a water bath previously heated to 40° C., and the contents of the flask are thoroughly shaken every half hour during the digestion. The solution is then filtered through a ribbed filter of two thicknesses of paper, refiltering the first portion, if cloudy. The filter should be large enough to receive the entire contents of the flask. Before filtering the contents, the flask should be well shaken. Four

hundred to 600 c.c. of the filtrate (at 20° C.) are evaporated to dryness after adding 1 to 3 c.c. of nitric acid. If there is any appreciable amount of organic matter present, the residue is to be carefully charred. Moisten the residue with hydrochloric acid and add 50 to 100 c.c. of distilled water, and then digest. Filter, neutralize with ammonia, add 5 c.c. of strong nitric acid and 15 grams of nitrate of ammonia in solution. Complete the determination according to one of the official methods given for the determination of phosphoric acid, or use the Goss method as given in Circular No. 4 to accompany Bulletin No. 46.

III. — Determination of the Available Phosphoric Acid in Soils by Means of a One Per Cent. Solution of Citric Acid (Dr. B. Deyer).

Preliminary Treatment. — Twenty grams of soil are digested with 200 c.c. of a one per cent. citric acid solution for five hours, at ordinary temperature (18° to 21° C.). The material is filtered and solution is titrated against a standard alkali solution, to determine the amount of acid neutralized by alkalies in the soil. For the estimation of the "available" potash and phosphoric acid, one per cent. citric acid solution has been employed, digesting 100 grams of air-dried soil with 500 c.c. of the solvent, as directed in the preliminary test, corrected for neutralization, for five hours at room temperature. The filtered solution is evaporated to dryness, charred, and the residue abstracted with dilute hydrochloric acid and water. The filtrate from this operation is treated for the determination of phosphoric acid as directed in one of the official methods.

IV. — Determination of the Available Phosphoric Acid in Soils by Means of a Neutral Solution of Citrate of Ammonia.

Ten grams of the soil are digested for one-half hour, at 65° C., with 500 c.c. of strictly neutral solution of citrate of ammonia, specific gravity 1.09. The flask carries a rubber stopper, and is thoroughly agitated every five minutes. At the expiration of thirty minutes, remove flask from bath and filter as rapidly as possible. Wash thoroughly with water at 65° C. Evaporate the solution to

dryness, char, and abstract with dilute nitric acid. Filter and wash thoroughly with water. Burn the residue to a white ash, add it to the solution and bring to complete dryness on sand bath. Take up with hot water and a few cubic centimeters of nitric acid. Digest for one-half hour. Filter and wash thoroughly, and determine phosphoric acid in the solution in the usual way.

Results of Analyses of Soils for Available Phosphoric Acid, by Methods previously described (Soil from Fields of Massachusetts Agricultural College Farm).

No. of Samples.	Moisture.	Total Phosphoric Acid.	Available Phosphoric Acid by $\frac{n}{5}$ Hydrochloric Acid.	Available Phosphoric Acid by 1 Per Cent. Citric Acid.	Available Phosphoric Acid by Neutral Citrate of Ammonia.
1, . . .	.77	.255	.0285	.01325	.0735
2, . . .	.87	.290	.0338	.01650	.0945
3, . . .	.95	.210	.0407	.01420	.0865
4, . . .	1.07	.220	.0330	.01920	.0925
5, . . .	1.02	.180	.0345	.01430	.1070

Analysts: Henri D. Haskins.
Charles I. Goessmann.

Conclusion.

The several modes used by us in determining the amount of available phosphoric acid contained in the soil under examination have given different results. The difference in the amount of available phosphoric acid found by any of the modes of analysis employed does not correspond with the actual yield of the several plats in the field. The results of our investigation are more of a suggestive than decisive character. The work will be continued as far as resources on hand will permit.

6. Analysis of Drainage Waters obtained from Field A of the Hatch Experiment Station.

The field under discussion has been from 1883 to date treated in a systematic way with commercial fertilizers, in the manner briefly described in the following pages. The

field consisted of eleven plats, one-tenth of an acre each, with a space of from five to six feet between the adjoining plats. This space was cultivated in connection with the planted plats, yet received no fertilizing material of any description, nor were they seeded down at any time during the experiment. Each plat was provided in the centre with a tile drain running at a depth of from three and a half to four feet through the entire length, which terminated in an open well, to allow the collection of the drainage water for examination whenever desired, to study the character of the soil constituents carried off. The entire field of eleven separate plats were surrounded by a tile drain with an independent outlet, to prevent an access of drainage waters from adjoining fields. A marked gradual decline in the yield of several plats, in spite of a uniform liberal supply of the fertilizer used during the earlier years of the experiment, rendered an examination into the cause or causes of the reduction in the annual yield desirable.

As an examination of the drainage waters coming from the different plats promised to throw some light on the action of the several mixtures of fertilizers used on the soil resources of the field employed in the observation, it was decided to subject them to a careful chemical analysis. The samples used for these analyses were collected in all cases as far as practicable soon after each tile drain began to discharge drainage water. As the temporary flow of the drains in the different plats differed widely in quantity, no attempt was made to ascertain in each case the exact amount discharged in a given time. The examination was instituted for the purpose of ascertaining the general character of the discharge of the drains, and to determine the *relative proportion of various soil constituents they contained.* The results of this investigation are stated farther on, after a brief description of the general management of the field, as well as a detailed statement of the fertilizers used.

Amount of Fertilizing Ingredients used annually per Acre.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	80 pounds.
	Potassium oxide,	125 pounds.
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	80 pounds.
	Potassium oxide,	125 pounds.

One plat, marked 0, received its main supply of phosphoric acid, potassium oxide and nitrogen in form of barn-yard manure; the latter was carefully analyzed before being applied, to determine the amount required to secure, as far as practicable, the desired corresponding proportion of the three essential fertilizing constituents. The deficiency in potassium oxide and phosphoric acid was supplied by potash-magnesia sulphate and dissolved bone-black. The fertilizer for this plat consisted of 800 pounds of barn-yard manure, 32 pounds of potash-magnesia sulphate and 18 pounds of dissolved bone-black.

The mechanical preparation of the soil, the incorporation of the manurial substances, — the general character of the latter being the same, — the seeding, cultivating and harvesting were carried on year after year in a like manner and as far as practicable on the same day in case of every plat during the same year.

The subsequent tabular statement shows the annual application and special distribution of the manurial substances with reference to each plat since 1889. The fertilizers were in every case applied broadcast as early in the spring as circumstances permitted. They were well harrowed under before the seed was planted in rows by a seed drill.

PLATS (One-tenth Acre).	Annual Supply of Manurial Substances.
Plat 0,	800 lbs. of barn-yard manure, 32 lbs. of potash-magnesia sulphate and 18 lbs. of dissolved bone-black.
Plat 1,	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

PLATS (One-tenth Acre).	Annual Supply of Manurial Substances.
Plat 2, . .	29 lbs. sodium nitrate (=4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 3, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. phosphoric acid).
Plat 4, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 5, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen) 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 6, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 7, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 8, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 9, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 10, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).

The above-described course of the general management of the experiment has been followed thus far for five consecutive years (1889–93, inclusive).

Kind of Crops Raised.

Corn (maize), ...	in 1889.
Oats, ...	in 1890.
Rye, ...	in 1891.
Soy bean, ...	in 1892.
Oats, ...	in 1893.

Amount of Fertilizing Ingredients applied per Acre during 1894.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen, ...	45 pounds.
	Phosphoric acid, . . .	160 pounds.
	Potassium oxide, . . .	250 pounds.
Plats 4, 7, 9, ...	Nitrogen, ...	none.
	Phosphoric acid, . . .	160 pounds.
	Potassium oxide, . . .	250 pounds.

Plats (One-tenth Acre).	Manurial Substances Applied.
Plat 0, . .	800 lbs. barn-yard manure, 80½ lbs. potash-magnesia sulphate and 77 lbs. dissolved bone-black.
Plat 1, . .	29 lbs. sodium nitrate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 2, . .	29 lbs. nitrate of soda (=4 to 5 lbs. nitrogen), 97 lbs. potash-magnesia sulphate (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 3, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 4, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 5, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 97 lbs. potash-magnesia sulphate (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 6, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
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Plat 8, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 9, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 10, . .	43 lbs. dried blood (=4 to 5 lbs. nitrogen), 97 lbs. sulphate of potash-magnesia (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).

Analysis of Drainage Water (Per Cent).

100 parts of total solids contain: —

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Potassium oxide,	.600	.380	1.210	.637	.700	.125	.544	2.080	.2740	.5100	.410
Sodium oxide,	21.630	23.850	50.180	5.310	16.670	6.290	6.960	20.890	13.6200	25.6400	5.000
Calcium oxide,	14.210	10.660	12.090	18.340	21.870	23.070	20.720	22.800	26.1900	20.7700	7.240
Magnesium oxide,	6.630	5.390	4.160	5.120	5.340	6.980	4.846	4.680	3.8750	3.9600	2.380
Actual ammonia,	.076	.027	.070	.023	.038	.021	.018	.031	.0068	.0100	.025
Albuminoid ammonia,	.525	.043	.108	.185	.077	.302	.338	.068	.0500	.0560	.073
Ammonia as nitrates,	.565	.242	.765	.349	.331	.298	.708	.153	.3920	.0289	.105
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	trace	.1210	trace	trace
Sulphuric acid,	20.260	2.010	22.810	7.920	1.470	52.820	18.970	6.090	5.7500	4.4600	28.530
Chlorine,	16.150	26.390	6.040	28.380	38.210	2.420	24.610	35.470	32.0700	36.4100	1.020
Silica,	7.700	3.580	.637	4.950	3.160	3.220	5.576	2.570	2.2260	2.8900	.864

Analysts: HENRI D. HASKINS.
ROBERT H. SMITH.

Drainage Water (Results computed in Percentages).

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Total solids,	.0080500	.0265000	.0182000	.0303000	.0256500	.0248000	.0260000	.0265000	.0530000	.0346000	.0787000
Potassium oxide,	.0000480	.0001000	.0002200	.0001930	.0001780	.0000310	.0001415	.0005500	.0001450	.0001770	.0003260
Sodium oxide,	.0017409	.0062205	.0091333	.0016100	.0042728	.0015600	.0018100	.0055366	.0072200	.0088740	.0039344
Calcium oxide,	.0012441	.0028259	.0021997	.0055600	.0056106	.0057200	.0053880	.0059319	.0138820	.0071880	.0057012
Magnesium oxide,	.0005333	.0014272	.0007567	.0015500	.0013693	.0017300	.0012600	.0012396	.0020540	.0013690	.0018738
Free ammonia,	.0000610	.0000072	.0000118	.0000070	.0000098	.0000052	.0000048	.0000078	.0000036	.0000036	.0000197
Albuminoid ammonia,	.0000420	.0000114	.0000198	.0000562	.0000195	.0000750	.0000880	.0000184	.0000267	.0001094	.0000432
Ammonia as nitrates,	.0000460	.0000640	.0001400	.0001060	.0000830	.0000740	.0001840	.0000410	.0002080	.0000100	.0000830
Total ammonia,	.0001490	.0000826	.0001716	.0001692	.0001123	.0001540	.0002770	.0000672	.0002383	.0001230	.0001459
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	trace	.0000640	trace	trace
Sulphuric acid,	.0016311	.0005322	.0041511	.0024000	.0003777	.0131000	.0049340	.0016139	.0030500	.0015450	.0224548
Chlorine,	.0013000	.0070000	.0011000	.0086000	.0098000	.0006000	.0064000	.0094000	.0170000	.0126000	.0008000
Silica,	.0006200	.0009500	.0011600	.0015000	.0008100	.0008000	.0014500	.0006800	.0011800	.0010000	.0006800

Without any intention to discuss here in detail the causes of the variations noticed in the composition of the saline residues left when evaporating a definite amount of the drainage water collected from the various plats, it remains of especial interest to call attention to the fact that wherever muriate of potash had been used as a potash source of plant food exceptional quantities of the chlorides of calcium and magnesium proved to be present (plats 1, 3, 4, 6, 7, 8 and 9). The belief that a liberal use of muriate of potash had resulted in wasting in an exceptional degree in particular the lime resources of the soil, and thereby reducing the yield of the crops, has since been confirmed. The annual yield of the crops has been restored to its former satisfactory condition, after a liberal addition of air-slaked lime to the manures used for years upon the field in question.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Scope of Work.

This division has during the past year made special effort to come into direct contact with a large number of market gardeners and greenhouse growers; and, largely as a result of this more direct contact and the numerous visits made to their establishments, our correspondence has during the past year doubled that of any other year, and has covered a multitude of subjects relating to botany.

We have paid some attention this summer to the asparagus rust, which caused so much damage in this State in 1897. A study of the conditions which caused the rust has been made at various places throughout the State, and spraying experiments have been carried on in co-operation with different asparagus growers.

The results of the study of nematode worms in greenhouses, which has received a great deal of attention by this division for over three years, have been published in Bulletin No. 55, which can be had on application. This

bulletin, containing 67 pages and 14 plates, gives a full account of the parasitic species of nematode, its life history and development, together with the results of an extensive series of experiments on the methods of controlling the pest. In these investigations the worthlessness of many supposed remedies has been brought out, and a practical method of treatment developed by which the trouble can be successfully and economically avoided. From a considerable amount of data accumulated during the last three years it appears that the loss experienced by cucumber growers who have been troubled with nematodes in the greenhouse equals 25 to 85 per cent. of the marketable crop; and it is hoped, from the positive results obtained, that little trouble may be experienced hereafter with this pest. There are still, however, some further experiments being made upon nematode-control methods, in co-operation with large greenhouse growers, along lines which promise cheaper and efficient results.

The principal investigations with which this division is concerned at present are largely in connection with market-garden crops such as are cultivated in greenhouses. The division is supplied with greenhouses excellently arranged for experimental purposes, and containing space enough to carry on investigations from which reliable deductions can be drawn. The more important greenhouse crops grown in our greenhouses for experimental purposes are those representing considerable importance in this State, namely, lettuce, cucumbers and tomatoes; and it may be justly said that there is no class of agricultural pursuits which is represented by men of greater intelligence, skill and knowledge.

A brief outline of some of the investigations may not be out of place: —

(*a*) Experiments on the control of the "drop" in lettuce, and a study of the little known habits of the fungus causing the same. A lettuce house, 40 by 12 feet, is devoted to these experiments.

(*b*) Observations on the "top-burn" in lettuce.

(*c*) Experiments on the mechanical conditions of the soil, as affecting the growth of lettuce.

(*d*) Sub-irrigation, as affecting lettuce diseases.

(*e*) Experiments on the pruning of cucumbers, in relation to the maturity and production of fruit; also, observations on the various fungous diseases of the cucumber, and the conditions which favor them.

(*f*) Experiments on the pruning of tomatoes, in relation to the production and maturity of fruit; a study of the fungous diseases of the tomato.

(*g*) Experiments on the growth of violets in sterilized soil and nematode-infested earth, with special reference to the relationship existing between the size, maturity and production of flowers in the plants, and abundance of leaf spots.

(*h*) Experiments with gases and chemical solutions for disinfecting greenhouses and repression of fungi.

(*i*) Further experiments on the relationship existing between electricity and plant growth.

There are a host of fungous diseases common to our out-of-door plants, some of which have received special attention, such, for example, as the asparagus rust, aster disease, etc.; but the practice of spraying fruit trees and garden crops has for many years been largely carried out by the horticultural division, which is well equipped with all of the modern spraying appliances.

A few years ago it was generally believed by the majority of people that botany was incapable of being made of any practical use, and it is doing no injustice to truth to state that it did possess little at that time. To-day, however, this state of affairs has entirely changed, and botany, like chemistry and other allied sciences, has taken its place in the industrial arts, — a fact which is due to the advance of science in general, but more especially to the inherent genius characteristic of the American investigator, which naturally emphasizes the utilitarian aspect of science. The annual loss in the United States to agricultural, horticultural and floricultural products caused by pathogenic fungi and their allies will probably equal $10,000,000. It is, therefore, not only important, but perfectly legitimate, that the principal work of botanists in our numerous experiment stations should consist in studying the life history of these organisms with

a view to their repression. In regard to the industrial side of botany, it should not be forgotten that it owes a great deal to the patient investigations of the many scientific workers of the past, who have devoted their attention to matters of purely scientific interest; and our stations would not be where they are to-day were it not for the labors of these men.

In connection with the characteristic utilitarian features of the present American botanists, it may be of some interest to observe the differences existing between European and American methods of combating pests. Some of the most effective spraying solutions were discovered in Europe, but the methods of applying them and the results obtained by their use to our crops far exceed anything ever accomplished there. To one who has paid any attention to the manner of growing plants in Europe and the methods which are pursued in the control of plant diseases, it would seem no exaggeration to state that more is accomplished in this direction in the United States in one year than in Europe in five years.

The past season has been what might be termed a normal one, although, as in every season, some fungi were especially predominant. There are, however, every year types of fungous diseases which affect our shade trees.

Pathogenic Fungi.

The fungous diseases which have been specially common upon our shade trees this last season are as follows: —

Black Spot of the Maple (Rhytisma acerinum, (P), Fr.).

This fungus is characterized by elevated black spots or blotches upon the surface of the leaf, and, while it is not uncommon to a few maples, it has been especially abundant on the silver maple.

Oak Leaf Blight (*Gloeosporium nervisequum*, (*Fckl.*), *Sacc.*).

A fungus apparently identical with that which causes the blight of the sycamore is sometimes found upon the white oak. This produces large dead blotches upon affected leaves, and causes great disfiguration of white oak trees.

Walnut Leaf Blight (*Gloeosporium Juglandis*, (*Lib.*), *Mont.*).

This disease was mentioned in our last report as having been especially abundant during 1897. It has also occurred this year, but to a much less extent.

These diseases are briefly mentioned because complaint has been frequent during the past summer in regard to them, largely, however, from people who possess shade trees which they value. From what we know in regard to the treatment of similar fungi occurring on other plants, it would seem that spraying might hold some of these in check; and the only reply which can be made is, Are the trees valuable enough to receive treatment? Some of these fungi attack large groves, and the expense of spraying would amount to considerable. As a rule, these fungi only make their appearance at intervals, and do not injure the trees to any great extent. In consideration of this fact, it appears questionable to us whether they are worth the trouble; but, should spraying be deemed necessary, it would have to be done early and continued each year.

The disease of the peach known as the "leaf curl" (*Exoascus deformans*, Fckl.) has been unusually abundant during the past season. This disease is well known to most peach growers, causing the leaves to become wrinkled and curled and greatly deformed, finally resulting in their falling to the ground. It is not ordinarily regarded as an especially destructive disease, and does not often cause any appreciable damage to the tree; but, when so abundant as to cause a large proportion of the leaves to fall, it cannot but injure the tree to some extent.

Another disease of the stone fruits, the so-called "plum pockets" (*Exoascus Pruni*, Fckl.), which causes young plants to become swollen and distorted in a peculiar manner, has been received several times this year. Besides the plum (*Prunus domestica*), the wild cherry (*Prunus Virginiana*) is also affected by the same fungus. The disease is not often very abundant, but occasionally causes a considerable diminution of the crop.

For methods of controlling the various diseases of the peach, plum and cherry, consult the spraying bulletin annually issued by the horticultural division of this station.

A Musk-melon Disease.

During the latter part of August our attention was called to a field of musk-melons, in which a destructive disease of the leaves had appeared and seemed to be rapidly increasing. The owner informed us that he had lost his entire crop the year before in the same way. It was evident that the trouble began in the centre of the hills. Here the leaves at the time of our first visit had in many hills wilted and begun to turn yellow and partially died. They were covered with yellow spots, or, in the worst cases, with dead areas of considerable size. At this time the general appearance of the field was good, the only very noticeably affected places being these centres of some of the hills. Still, it could be seen on closer examination that scarcely a leaf in the whole field was entirely healthy. On almost every one there were small yellow spots, more or less abundant, some were slightly wilted, and it was evident enough that the disease was spreading in each hill from the centre outward. The dead areas on the most affected leaves were dry and brittle, marked with slight concentric rings, and a dark, mould-like growth could be seen upon them. Examined with the microscope, this proved to be a fungus, and a species of *Alternaria*. It grew abundantly in the tissue of the leaf as well as upon the surface, where the dark-brown, club-shaped spores were produced. No other fungus or other organism could be found on the affected leaves, and there seemed but little doubt that this was the direct cause of the trouble. Furthermore, Dr. W.

C. Sturgis,* who describes what is evidently the same disease in Connecticut, has succeeded in producing it by inoculating sound leaves with the fungus, thus leaving no doubt that the *Alternaria* is the cause of the trouble. This fungus is a mould-like growth, consisting of a mass of fine filaments which grow upon and in the leaf, consuming its substance and vitality. It reproduces itself by the above-mentioned spores, which are blown by the wind from the surface of the affected leaves to fresh ones, and there germinate and produce the disease. It is not entirely clear why the leaves near the centre of the hill should be the first to show the disease, unless, perhaps, it is because they are the oldest leaves, and thus are growing less vigorously than the outer ones, and less able to resist the attacks of such a fungus. It should not be supposed that the disease spreads outward to the other leaves through the plant itself, as the nature of the fungus shows that this is not the case, but that it spreads entirely by means of the spores which are carried through the air.

As the disease was so far advanced when we first saw it, it was pretty evident that no treatment would be of much avail in checking it. A portion of the field was sprayed with Bordeaux mixture, but the weather continued, as it had been for some time previous, very rainy, and before a second spraying could be made almost every leaf in the field was dead and withered. Some of the melons had reached sufficient size to mature, but nothing like a full crop was obtained. The same disease was met with in one other locality during the season, and no doubt occurred in various parts of the State, though melon-raising is not much practised here. There is no apparent reason why this disease should not be as successfully treated by spraying with Bordeaux mixture as are many similiar ones which are largely prevented by this means. Experiments will be made another season by spraying at the time of blossoming, and several times thereafter during the season. Knowing the nature of

* Report Connecticut Agricultural Experiment Station, 19 (1895), p. 186, and 20 (1896), p. 267. See also Ohio Bulletin 73, p. 235, and 89, p. 117; Journal Mycology, vii, p. 373.

the disease, it will of course be at once understood that it is very advisable to destroy all affected vines and leaves by burning. It might also be safer not to plant melons on land where the disease had already occurred during the previous season. We do not, however, lay great stress on this, as many farmers have a particular area especially suited to this crop, which they do not like to give up, and the disease is probably disseminated widely enough so that it is about as likely to occur in one place as another.

Rotting of Cabbage.

The rotting of cabbage in the field, caused by a species of bacteria, which has recently been so thoroughly investigated by Russell* and Smith,† appeared this year in a field upon the station grounds, and also occurred to our knowledge in several other places in the State. It is a most destructive disease, causing dead spots to appear upon the outer leaves of the cabbage, and usually resulting in a complete decay of the whole head. Cauliflower is quite susceptible, as also cabbages and turnips. A full description of the disease may be obtained in the above-cited Farmers' Bulletin, which can be obtained upon application to the Secretary of Agriculture, Washington, D. C. No practical remedy is known except a rotation of crops. As the disease occurred here on land which had never been in cabbages before, even this seems rather uncertain.

Further Considerations in Regard to the Drop in Lettuce.

We have already referred to this disease in our last annual report, and it may not be out of place to briefly call attention to the progress which has been made towards the control of this troublesome fungus. The study of the organism which causes the disease has given some suggestive results in regard to its treatment. The ordinary "damping fungus" (*Botrytis*), has been generally regarded as the source of the trouble, and we have so referred to it in our previous report. Further observation has shown, however, that, whatever may

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* Bulletin 65, Wisconsin Experiment Station.

† Farmers' Bulletin 68, United States Department Agriculture.

be the relation between the drop fungus and *Botrytis*, it is certain that the disease is not spread by *Botrytis* spores in the air, but by a mycelium or mould-like growth in the soil itself.

Our control experiments have so far been along three different lines; namely, those in which chemical substances were used on the soil, the application of various gases to the greenhouse, and the effect of different layers of sand and sterilized earth. The results obtained by the use of chemical substances have been entirely negative, and the use of gases does not at the present time give great encouragement. In our last report we called attention to the use of sterilized soil as a possible control method, and during the past winter and also at the present time this method has been in use. Our experiments have shown that the heating method is the only absolute one, although some gain has been made by the use of three-fourths of an inch of sand upon the beds. The sand which was sterilized showed better results than the unsterilized. In both instances, however, cleaner and better plants have been obtained by the use of three-fourths or one-half of an inch placed upon the surface of the soil. Experiments in which three or four inches of the top soil was sterilized gave absolute results in the control of the drop, and those in which two inches of the infected top soil was sterilized have not as yet shown any evidences of the drop. Where one inch of sterilized soil was used and carefully distributed, the loss from the drop has been about four per cent., while in the adjacent beds which were not sterilized the loss was about fifty per cent. These experiments have been carried out in another badly infested house, managed by an experienced lettuce grower, on a much larger scale, with quite similar results.

While this method gives promise of being a practical one, we are not quite certain as yet whether it is the cheapest one which can be utilized, and other control methods are being experimented with. Some growers clean their houses out every year, and put in fresh subsoil mixed with horse manure; but such a method is expensive, probably more so than the heating of an inch or two of the top soil previous to planting

the crop. If one is provided with a good steam boiler, as most lettuce growers are, probably two hundred cubic feet of soil could be heated sufficiently in one or two hours' time. This amount of earth will cover twenty-four hundred square feet of soil one inch deep, or a bed twenty-four feet wide by one hundred feet long. Of course this heating will have to be done with every crop, as the stirring of the soil subsequent to planting would redistribute the fungus. As a necessary precaution against the drop, it would also be necessary to have all the soil sterilized in which the prickers are started, and also that which contains the first transplanting. By this means alone much lessening of the drop could be accomplished; but in conjunction with sterilized layers one inch thick in the house, it would in most cases reduce the infection still further. The amount of earth that is employed in the seed bed and also that in which the first transplanting is done is not so large but that it could be entirely sterilized. When this is once accomplished, it would be sufficient for some time to come, provided precautions were taken against outside contamination. The benefits gained from the use of sterilized soil are in themselves, regardless of the drop, sufficient to pay for the process, according to some who have used it, inasmuch as the lettuce plant shows a better color and makes a quicker and larger growth.

The Chrysanthemum Rust.

This comparatively new disease has been not uncommon in the State during the past season; but it is encouraging to note that its attacks seem in most cases where it has occurred to have had but little appreciable effect, and the indications now are that this disease is one which may be fully controlled by proper methods of cultivation and management. We noticed especially a case where a lot of plants were brought in in August to set out in the open bed for fall blooming. Fifteen plants were left over, and remained standing on a greenhouse bench in pots. Later in the season this bench was filled up with other potted plants which had remained out of doors. Though all were of the same lot, the fifteen became badly rusted, while none of the others or

those set out in open beds showed any signs of the disease. It seemed pretty evident, therefore, that the high August temperature of the house had a bad effect upon the plants confined in pots, causing them to be more susceptible to the disease. Some of the plants which were still out of doors in a cold frame also became rusted, but these were crowded together so that all the lower leaves had fallen off, and were plainly in poor condition. Of the many plants which were set out in open beds in August or placed on benches with space between them in September, not one showed any noticeable rusting.

It remains to be said that the rusted plants, though badly affected, produced blossoms as good, apparently, both in quality and quantity, as similar healthy plants, and, furthermore, did not spread the disease to other plants, though kept in close proximity to them. Judging, therefore, from this year's experience, it seems probable that the skilful gardener has no great cause for apprehension in this disease.

A New Pansy Disease.

During the past summer our attention was called to a field of pansies at the establishment of a local seed grower, in which the plants were badly affected by a disease of the leaves and blossoms. Upon the affected leaves first appeared small dead spots, each surrounded by a definite black border. These spots soon increased in size, and in the later stages of the disease the affected leaves had an appearance very similar to that of the violet leaf spot (*Cercospora Violæ*, Sacc.). Many plants were killed outright by the disease, and all affected ones were in very poor condition. Besides the spotting of the leaves, many of the blossoms also were affected, the petals being disfigured by dead spots and blotches upon them, while some of the flowers were malformed or only partly developed. The latter was indeed one of the most serious features of the trouble, as the plants were raised for seed, and the yield was greatly reduced by this failure of the blossoms to develop properly.

It was thought at first, from the general resemblance of the leaf spots and close relationship of the two plants, that

this might be identical with the violet disease. This, however, did not prove to be the case. Examination showed that the cause of the trouble was a fungus, but one of quite a different nature from *Cercospora*, and belonging to the genus *Colletotrichum*, being apparently a new and undescribed species. This form has therefore been described in the "Botanical Gazette" of March, 1899, under the name *Colletotrichum Violæ — tricoloris*.

This same disease has been seen in a few other localities in the State, and Prof. B. D. Halsted has also very kindly sent us specimens of it from New Jersey, so that the trouble is doubtless widespread. Its occurrence, however, seems to have been comparatively slight, except in the one instance described above. In this case the number of plants was very large, and pansies had been grown upon the same field for several years, which may account for the severe outbreak of the disease.

A portion of this field was sprayed twice with strong Bordeaux mixture; but, as it was already late in the season, and heavy rains prevailed at the time, little success from the treatment was looked for. The owner, however, thought that a beneficial result appeared from the treatment, and from our own observation we can claim at least that later in the season the sprayed portion of the field was certainly in the best condition of any. If this did indeed result from the spraying under such adverse conditions, it seems likely that the disease could be kept well in check by proper treatment.

Physiological Disorders.

Seasonal Peculiarities of Certain Shade Trees.

Some complaints have been made in regard to the falling of leaves on the elm, maple and apple trees. This was especially noticeable on the elm in various sections. We had many specimens sent in for examination, and our attention was called to a number of trees in which certain branches had only half-developed leaves on them. These leaves would linger along a while in this condition, when they would gradually turn yellow and drop to the ground.

Examination made of a great many leaves and branches revealed no fungous or insect pest preying upon them. The condition of the apple trees was similar, although not so prevalent; and in the maple the cast-off leaves were mature ones. The exact cause of this trouble is not obvious, but there can be little doubt that it was a functional disorder. We have observed fine specimens of elm trees, which, after a period of excessive seasons, would suddenly lose all their leaves in midsummer, yet a year or two later would appear as vigorous as ever. Inasmuch as the trees are not materially injured by the falling of a few leaves in midsummer, remedial measures are not necessary.

Over-feeding of Plants.

The over-feeding of plants is not an uncommon occurrence at the present time, when so much concentrated fertilizer is used, and where attention is not given to the proper amounts that should be employed. This trouble not only occurs among florists, etc., but among those who cultivate house plants as well; and the cause of the trouble is usually traceable to the fact that most people are not aware of the strength of the constituents serving as plant food. The normal strength of chemically pure solutions, available for plants, is about one to one thousand or one to two thousand parts, and when these solutions are put on at the rate of one to one hundred or so, ill results must be expected to follow their use.

We now and then have specimens of abnormal plants sent in to us which are merely suffering from some such treatment. A potted specimen of a Johnsonian lily, which had a number of reddish eruptions or blisters upon its leaves, was sent in for examination. These reddish blisters were examined under the microscope, and they showed no evidence of fungi or insects being present. The cells, however, in the vicinity of the blisters showed that they had been stimulated exceedingly, which manifested itself in excessive cell division, giving rise to the blisters; and where this action had taken place excessively the tissues were ruptured, thus producing a ragged, wounded appearance. This trouble

could be readily referred to some abnormal features in connection with nutrition, and an inquiry showed that the plants had been heavily fertilized with Chili saltpetre. The same treatment was applied by us to a perfectly healthy Johnsonian lily, with the result that the same activity was shown in the division of the leaf cells, which subsequently gave rise to blisters or ragged eruptions identical with those described.

A number of potted specimens of cyclamens grown by a florist were also brought to our notice last winter, which showed somewhat similiar peculiarities in the leaf. These leaves were blistered, although in quite a different manner from the Johnsonian lily mentioned above. There were no ragged or lacerated eruptions or pustules on the cyclamens, and the manner of blistering was quite different, although it was evidently caused by over-feeding, or at least by injudicious feeding, as it was found that the plants had been heavily treated with nitrate of soda.

A singular case of over-fertilizing or perhaps over-watering was seen in some specimens of carnations sent in to us by a grower. We subsequently visited the greenhouse where they were found, and had an opportunity of seeing these abnormal plants in the benches, beside other plants of the same variety that were not affected. About fifty plants in this house showed this trouble, and it was confined to the most robust specimens of the variety known as the Edith Foster, and in some instances to the Mrs. Fisher. The characteristics of these diseased plants were whitish stems and foliage, which were enlarged to about twice the size of normal ones growing next to them. Repeated examinations of the tissues of the affected plants seem to show that there was nothing the matter with them except what might be expected from improper nutritive conditions, such as might be brought about by too much fertilizer or excessive watering, which caused the plants to be stimulated abnormally in their growth. In the spring the plants were removed from the greenhouse into fresh garden soil, but they failed to recover. The same variety of carnations has already shown similar symptoms this season.

Injudicious use of fertilizers is not an uncommon matter,

and more care should be exercised in their application. Most fertilizer companies give explicit directions as to the amounts which should be employed, and the excessive use of them is generally traced to the carelessness of the gardener in applying them. The results of over-feeding generally manifest themselves in some abnormal stimulation to the plant; but these results, even when the same fertilizer is used, do not show themselves in a similar manner on different species of plants. What would give rise to a multiplication of cells and the formation of blisters in the leaf of one plant, would not do it in the leaf of another. In short, stimuli in plants manifest themselves specifically and manifoldly.

The Bronzing of Rose Leaves.

A peculiar bronzing or irregular spotting of rose leaves was brought to our attention last winter by Mr. Alexander Montgomery, Jr., a member of the senior class. This peculiarity in the spotting or bronzing of the leaf is common to grafted varieties of the Tea, Bride and Bridesmaid roses, grown at the extensive Waban conservatories at Natick; and Mr. Montgomery, who was working in the botanical laboratory at that time, made, at my request, some investigations into the cause of the trouble. Both Mr. Montgomery and his father, who is in charge of the Waban conservatories, have had ample opportunity to observe bronzing; and it therefore became a very easy matter to secure valuable data. The only mention which we have noticed in connection with this disease is that given by Professor Halsted of New Jersey, who briefly referred to it in his annual report of 1894.* In this report he gives a figure of the black spot of the rose, and in connection with it is shown what he designates a "discoloration that is most frequently met with on the foliage of the La France, and may be called bronzing." This he states, so far as he knows, is "not due to any fungus, and is likely due to a structural weakness." This reference to the disease by Professor Halsted was not observed until Mr. Montgomery had finished his investiga-

* New Jersey Experiment Station Report, 1894, p. 384.

tions; and, in order to ascertain whether the trouble with which we were concerned was the same which he had briefly alluded to, we forwarded him specimens for examination, which resulted in establishing the identity of the two. There is a certain resemblance between the spots which give rise to bronzing and those which are caused by the black spot; and we found that the impression prevailed among some rose growers that bronzing was simply an immature stage of the black spot. To any one thoroughly familiar with the characteristics of both diseases, the differences between them would be evident, and they would not be likely to confound one with the other.

The investigations of Mr. Montgomery showed that the abnormal condition of the rose leaves subject to bronzing was not in any way connected with fungi, but is of a physiological nature, or structural weakness, as Professor Halsted had correctly surmised. The first symptoms are manifested in a mottled, bronzing coloration of the leaf. These spots subsequently become more prominent, ranging from one-sixteenth of an inch to one inch in size; the infected portions of the leaf frequently turn yellow, and eventually the leaflets and leaf stalk drop to the ground. Sometimes, however, a whole leaflet becomes bronzed, and the yellowish color is not observed. Numerous microscopic cross-sections made of the bronzed leaf spots showed that the epidermal and adjacent cells were in an abnormal condition. The living contents of the cells were disintegrated, the protoplasm and cell walls had turned a reddish-brown color, and numerous very minute bodies about the size of micrococci filled the affected cells. These minute bodies proved upon examination to be crystals of calcium oxalate. The excessive deposits of calcium oxalate indicate that the leaf cells, being unable to obtain sufficient nourishment, were not able to assimilate the calcium salts, and consequently it is deposited in the cells in the form of calcium oxalate. It may be said that all of this phenomenon is nothing extraordinary, but merely concomitant with the death of the leaf, and can be observed in other species of plants. Mr. Montgomery states that the bronzed leaves are more susceptible to disease,

and he has observed the occurrence of rust upon them, while healthy leaves would be entirely free.

A further examination of the affected plants at the Waban conservatories, made by Mr. Montgomery and myself, showed that all leaves even of plants subject to it were not affected, but that it was confined in every instance to two places: first, where a stem is cut and a new branch starts, the leaf at the base of the branch begins to bronze; second, when an eye or axillary bud is rubbed off, the leaf generally becomes bronzed.

There is a difference in susceptibility between young plants and old ones. Roses planted in the middle of June show bronzing the first of August, but it is scarcely noticed after the first year's growth. Bronzing appears to occur more largely upon plants which show rapid growth than on those which have grown more slowly; for this reason apparently the root plants or ungrafted ones at the Waban conservatories which are not so vigorous as the grafted ones are not susceptible to it. Bronzing sometimes occurs upon small, weak stock.

It should be stated, however, that, since bronzing occurs on leaves at the axils of the shoots which bear the flowers, no real harm is done to the marketable foliage, as the cutting of the flower stalk is always above the position of the leaves which are bronzed. The most intelligent and successful rose growers always take the most care and pride in their plants, and they are suspicious of any abnormal feature which in any way mars the beauty of them; and this is, so far as we have observed, the only inconvenience which this trouble of bronzing gives rise to.

It is quite evident that we have in the bronzing of rose leaves a physiological phenomenon which is not uncommon to other plants. We have observed a similar falling of the axillary leaves in other species of plants. In the rose it is probably a correlative phenomenon, which is brought about, or at least augmented, by years of cultivation and development along certain lines. Any form of mutilation, whether it be a cut or a mere scratch, acts as a stimulus to a plant; but the manner of reaction of the plant may not always be

the same either in kind or degree. As a rule, the cutting of primary organs, such as a shoot, will give rise, among other things, to increased activities in the secondary organs, such as a side shoot or side root; and conversely the cutting of a secondary organ or branch will stimulate the primary organ or main shoot. Then, again, the effects of stimuli caused by cutting are more marked near the source of injury, and less marked the further away an organ is from it. For example, the cutting of the main axis near an eye or bud would give rise to increased activities in the axillary bud, which would manifest itself in the development of a new shoot. The nearer the cut to the eye or bud, the more marked will be the stimulation, or resultant activities, and the more completely will it assume the characteristics of the primary shoot. The better condition the plants are in, and the more suitable and available plant food with which they are supplied, the more rapid will be the growth of the shoot, and the more marked will be the correlative effects. Such, in fact, are some of the laws governing correlation in plants.

In the case of the bronzing and subsequent death of the axillary rose leaves, the stimulative effect of cutting causes a marked growth of the shoot, and the nutritive substances are thereby utilized by this organ to such an extent that some other portion of the plant is made to suffer. In this instance it is the axillary leaf which finally becomes bronzed, turns more or less yellow and dies. In other words, bronzing is nothing more or less than a physiological disorder, and falls under the domain of plant irritability.

Cucumber Wilt.

The growing of cucumbers under glass is carried on extensively in some places in this State, and a disease known as the wilt has been reported to the station a number of different times. Complaints in regard to this disease have always come from certain localities where it has, as a rule, been quite universal among the different growers. The symptoms of the disease are a wilting of the plant, or, more strictly speaking, of the foliage, whenever it is subjected to the intense rays of the sun.

We visited several cucumber houses this last spring in which the plants were subject to wilt, and observed a number of houses which contained badly affected plants. In those houses running north and south, the vines in the morning on the east side, which are subject to the sun's rays, would be entirely wilted; while those on the west side, and away from the sun's rays, were not in the least affected. In the afternoon, when the sun had reached the west side of the house, the vines would then become badly wilted, and those on the east side, when no longer exposed to the direct rays of the sun, would commence slowly to recover. The cause of the wilt in every instance was not difficult to understand; but, as a necessary precaution against drawing deductions too hastily, we examined every portion of a number of plants very carefully, to convince ourselves that there was no other cause than that which we had in mind. It is well known that there is a bacterial disease of cucumbers that gives rise to a wilting of the leaves, but careful examination of the tissues shows nothing in the nature of bacteria to be present.

At about the same time we visited several other cucumber growers in other sections of the State, and had an opportunity of examining many vines in about the same stage of development. In some instances the identical varieties of cucumbers were grown, but in the majority of cases another variety was used, namely, the White Spine, and in all cases the methods of cultivation were radically different, and the wilting of the vines was something unknown to them. Long before we visited the region of wilt a number of letters of inquiry had shown us that the disease in question was local, and the majority of growers had never had trouble with it.

The cause is not due to any organism, whether insect or fungous, but to extremely abnormal conditions of the plants, brought about by irrational methods of cultivation that give rise to defective transpiration, or, in other words, to the giving off of water from the leaves. The activity of transpiration is affected by various causes. It is well known that the stomata or breathing pores of the leaf are open during sunshine and closed during darkness, and that the greatest

activity in transpiration takes place during sunshine. This fact is frequently demonstrated by young cucumber plants in tolerably good conditions of health, which not infrequently show some indications of wilt in sunshine, though not enough to cause any amount of harm. This is especially so when they are forced too rapidly, and when the texture of the leaf is not sufficiently developed. The temperature of the air affects transpiration. A plant in an atmosphere saturated with moisture will not exhale any watery vapor, provided that the temperature of the plant is not higher than that of the air; but when the temperature of the air is high, and the proportion of moisture small, transpiration is promoted. Transpiration is further affected by the temperature of the soil in which the roots are embedded. When the roots are warmed, transpiration becomes more active, and consequently there exists more root absorptive activity. The nature of liquids which the roots absorb and the kind of soil in which they grow also affect transpiration. Plants transpire more when grown in sandy soil than when grown in clay soil; also when grown in acid soil than when grown in alkaline soil. One per cent. solutions of potassium nitrate and other salts diminish transpiration, and we have been able to produce severe cases of the wilt by watering pots of cucumber plants with a one per cent. solution of potassium nitrate.

The wilt, however, in the houses mentioned before was not due to temperature or constituents of the soil, but was brought about, as we have already inferred, by irrational methods of treatment of the plants, and depends upon other causes. In all probability, the cause of the wilt may be attributed partially to the characteristic peculiarities of the varieties of cucumbers grown, as most of the varieties are Telegraph or Giant Pera. In many cases hybrid forms are obtained by crossing these with the White Spine. These varieties present a different appearance from the White Spine; their stem and leaves appear to be small, and the plants do not appear normally as green and rugged as the White Spine.

The methods of growing cucumbers where the wilt occurs

are radically wrong in many ways. The houses are imperfectly supplied with ventilation, consequently little use can be made of this necessary feature. Then, again, they are supplied either wholly or partially with two layers of glass, which are set about two inches apart, thus leaving an air space in between for the purpose of keeping out the cold, but which in reality becomes filled up with dirt, and is an excellent aid in shutting out the light. Plants started in such a house in winter continually suffer from lack of light, — a feature which we have often observed in the greenhouses in this State. Their leaves become pale, and they are attached to the stalk by means of elongated petioles, and present all the phenomena of partial etiolation, or, in other words, they resemble plants grown in the dark. If we add to such plants an enormously high temperature, without any proper ventilation to make them stocky and rugged, then we have a crop that is so tender and abnormally matured that it is incapable of standing strong sunlight. If such a crop is carried over until spring, and subjected to the intense rays of the sun occurring in that season of the year, the tender, etiolated, sickly colored leaves commence to wilt even with the house closed and a considerable degree of moisture.

We observed as many as a dozen houses last spring affected in this way, and not in a single one did we see more than a dozen or so of what might be termed fairly good-colored and healthy plants. Whenever we observed a plant which possessed any color or texture in its leaves, we found plants which showed no indication of the wilt. We examined at the same time in another locality a crop of a similar variety of cucumbers grown in a house provided with a single layer of glass, which had also received sufficient ventilation, and the plants were in an exceedingly vigorous condition.

These facts show what it is always necessary to bear in mind, that some varieties of plants can be grown by different growers with entirely different results, and that it is essential to pay the greatest attention to conditions which are normal to the plants.

While the cause of the cucumber wilt is due, as we have

already pointed out, to irrational methods of greenhouse management, the specific cause can be traced directly to the lack of texture in the plants, brought about by too high a temperature and lack of light in the beginning, which does not enable them to stand up under the powerful rays of the spring sun, as the amount of water thrown off from their tender leaves is more than can be supplied by their roots. This irrational method seems to have its origin in a desire to save coal, and starve the plant by utilizing double layers of glass, and to indulge in too much forcing; or, in other words, to get more out of the plant in a certain length of time than its inherent capacity warrants. In these methods of culture, affecting, as they do, a single locality, we see nothing but practice based upon a disregard of the normal functions of the plant, and mistakes due to local conception of greenhouse management. The remedy in such a case is obvious, and consists in giving the plants during their young stage of growth plenty of light and air, and not allowing them to grow too rapidly. Cucumber plants grown in this manner will possess color and texture, and they will be capable of standing the spring rays of the sun without wilting.

Some Difficulties which City Shade Trees have to contend with.

For some years back our larger cities have had park commissions, whose duty consists, among other things, in seeing to the setting out and caring for shade trees. Many of these cities, having seen the necessity of a more general oversight in regard to the care of trees, have gone a step further, and have secured the services of a trained forester, whose business it is to pay special attention to their welfare.

This department frequently has specimens of diseased leaves and branches, especially of trees, sent to it for the purpose of determining what is the matter with them. Sometimes these specimens are from trees in which a single branch has lost its leaves in mid-summer, or they may be specimens from a tree which has died suddenly. An examination of the specimens frequently shows that there is no reason for believing that their abnormal condition is caused

by either insect or fungi, although at times there may be observed a few aphids on them, which it is generally supposed are the cause of the trouble. The causes of these troubles, however, are in many instances to be traced to conditions which are peculiar to our times. In this age of electric lights, trolley cars, sewers, pavements, gas, and transmission of steam for heating purposes, it must be confessed that the practice of setting out shade trees along the borders of streets in our cities becomes rather discouraging. The price of enjoying these modern appliances of scientific thought means more than the mere cost of digging up our city streets and lopping off the limbs of trees every few months; in many instances it means the death of many shade trees, and it may eventually lead to the question whether it is worth while to bother at all with trees for our city streets. The sickly, disfigured, mutilated specimens of trees which are now and then seen in our busy city streets have very little to recommend them, and in many cases thoroughfares would become improved without them.

Some of the agencies which more especially affect our trees are electricity, gas and steam. These may affect the tree directly, by escaping and coming in contact with some portion of it, or indirectly as by the lopping of limbs for wires or the digging of trenches for the pipes, which very frequently results in destroying portions of the root system. There are other agencies, however, which are associated with the death of the tree. One of these is the borer that is very troublesome to the rock maple. Trees affected with these can be readily detected by an examination of the bark of the tree for round holes about one-quarter of an inch in diameter, and in autumn the affected limbs can be readily detected by a premature coloration, or hectic flush, as it were, of the leaves. Then, again, there is the work of horses' teeth, which, according to Mr. James Draper, who has had many years' experience as a park commissioner at Worcester, inflicts more damage than any other single thing to city trees. Many of the specimens of diseased shade trees which are sent in to us year after year can be referred to one of the above agencies as a cause of the trouble.

The death of many trees can be referred to illuminating gas. If a leak occurs in the pipe, the gas escapes very readily into the soil, especially if it is porous, and when it comes in contact with the roots they are asphyxiated, and the result to the tree manifests itself very quickly. The symptoms of gas poisoning are most generally a sudden falling of the leaves, a deadened appearance of the bark, due to the collapse of the cambium or living layer, brought about by the asphyxiation of the roots, which results in the rapid death of the tree. In mild instances of poisoning the effect shows only upon one side of the tree, but in general the tree seldom escapes death. We have observed many single trees killed by gas on the private grounds of city residences, without the owner ever surmising what the trouble was; and this last summer we had an opportunity to examine whole rows of native trees which had died by gas asphyxiation. Some of the trees which we observed were at a distance of fifty feet from the nearest gas main, while others succumbed when not nearer than one hundred feet to the leak in the pipes. While it is advantageous to all gas companies to stop these leaks as soon as they are found, it becomes practically impossible to do so in every instance, and the death of trees from this source must constantly be expected. As a matter of fact, the death of some fine shade tree is not infrequently the first indication the gas company has of a leak in its main.

Abnormal respiratory conditions, which usually result in either a sudden or lingering death to trees, occur where they have become submerged in water, or where they have been covered with a foot or more of soil. We have noticed trees growing beside sloping roadsides which had become filled in with earth only on one side of the tree, resulting in that side of the tree becoming dead, while the other side would linger along in an unhealthy condition for years.

Less often does the death of trees result from steam, as the transmission of this is not so common. Occasionally, however, where steam pipes are laid near trees, they are sometimes injured.

The various forms of concrete and pavements and the large

surface of the ground covered by them about the city streets are a menace to the health of trees, and the sickly conditions which they present are often due to these. Some of our more modern city streets obviate this matter by leaving a wide space of turf between the sidewalk and road, for the purpose of planting trees. This gives the roots a chance to develop normally, inasmuch as the respiratory functions are not interfered with, as is the case when they are covered with pavements. Many of the streets in Springfield are especially commendable in this direction.

Not a little of the disfiguration of trees is directly due to the linemen in lopping limbs, and more especially to the direct effect of electric currents. We have observed no instance where electricity has killed a tree outright, but there are many cases where the limbs have been killed by burning. This effect is not only caused by the alternating current of the electric lights, but by the direct current of the trolley system; the latter current being probably more injurious, provided the same amount of amperes and voltage is employed. The damage done by grounded wires takes place when trees are moist, as at that time the resistance is reduced, and the current becomes increased and has a better opportunity to become dispersed. We have known of instances where trees and the grass for some distance about them have been charged with the escaping current. The damage to the trees, however, is due to the heating effect of electricity. The wire becomes grounded on a limb, and when moist the current escapes. At first comparatively little current passes through the limb, as the resistance is high; but, as the heat increases the resistance decreases, with the result that a large amount of current passes through, which gives rise to still more heat, and subsequently develops into a blaze. The action of electricity, as we have already stated, is local in its effects. The injury, while sufficient to kill every portion above the limb or trunk, does not, so far as our observation goes, destroy the tissues very far above the point of grounding. There are reasons for believing, however, that the effects of the direct current are more severe than those of the alternating current. In the case of

the alternating current the anode and cathode alternate very quickly, while in the direct current no alternation takes place, and this results in an electrolysis of the cells, which in turn produces disintegration and quick death to the protoplasm. In short, we may say that all of the injury to trees by electricity is brought about by heating, and by electrolysis and disintegration of the cell contents. Some observations made by Professor Hartig of Munich upon the effects of lightning on trees are interesting in connection with the subject of electricity. He observed that when a tree is struck by lightning the current usually travels along the cambium zone or living layer of the tree, just under the bark, inasmuch as at this point the current finds the least resistance. Sometimes the burning effect is more marked just inside and outside of the cambium layer, where the resistance is slightly greater, — a feature which is shown by the dead areas in the trees many years after. There are many trees struck by lightning which show scarcely any injury, and others will show only a small dead area which coincides with the path of the current. Professor Hartig has made many observations upon trees struck by lightning, and his practised eye is able to detect trees that have been so affected which to the ordinary observer would appear perfectly sound.

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OF THE

HATCH EXPERIMENT STATION

OF THE

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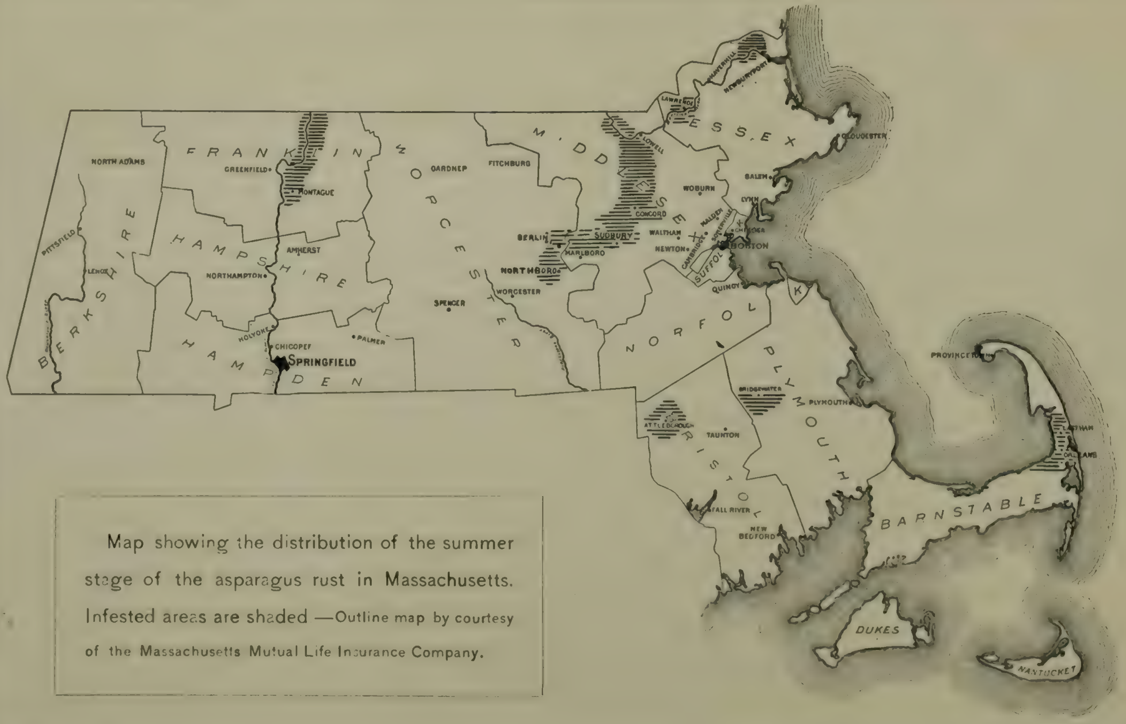

Map showing the distribution of the summer stage of the asparagus rust in Massachusetts. Infested areas are shaded.—Outline map by courtesy of the Massachusetts Mutual Life Insurance Company.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are : —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Henry T. Fernald, Ph.D.,	*Associate Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant in Foods and Feeding.*
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 37. Report on fruits, insecticides and fungicides.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 43. Effects of electricity on germination of seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
No. 52. Variety tests of fruits; spraying calendar.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 58. Manurial requirements of crops.
No. 59. Fertilizer analyses.
No. 60. Insecticides; fungicides; spraying calendar.
No. 61. The asparagus rust in Massachusetts.
No. 63. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888-95.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

The usual variety of problems have presented themselves for solution. In the agricultural division some interesting data have been collected on the use of sulfate and muriate of potash as fertilizers. With the sugar beet the larger yield was secured from the muriate, but the percentage of sugar was greater and the juice was of a higher degree of

purity, presenting less difficulties in manufacture, from the sulfate. In sweet and field corn there was no perceptible difference in product, quality or food value, but with cabbages the yield was much greater from the use of the sulfate. In the tests of potatoes the Beauty of Hebron and Early Rose still rank in 94 varieties among the most productive sorts, either for early or late harvests. In feeding poultry a narrow *v.* a wide ration for egg-production, the results seemed to be largely in favor of the wide ration, richer in corn meal and corn, in the following particulars: (*a*) lower cost of feed, (*b*) a gain of 23 to 91 per cent. more eggs, (*c*) a lower cost per egg, (*d*) a greater increase in weight and (*e*) a much earlier moult.

In the meteorological division, besides the usual observation of weather phenomena, the means of the various weather elements for the last ten years have been tabulated, and normal conditions for the period deduced. Observations relating to soil temperature and moisture by electrical methods have been continued, and results from the corn-growing season of the current year have been worked out to serve as basis for comparison in succeeding years.

In the horticultural division, experiments have been carried on in the use of hydrocyanic acid gas under glass as an insecticide, but definite results have not yet been secured.

In the entomological division, the card catalogue to the literature of North American insects now numbers over forty thousand. The inspection of nurseries for the San José scale and the granting of authorized certificates has been added to the work of the division; bulletins on the coccid genera Chionaspis and Hemichionaspis and the grass thrips have been issued, and one on the clover-head beetle and a monograph of the Pyralidæ are ready for publication. The composition of Raupenleim, formerly imported at a high price, has been determined, and it can now be made at a trifling cost.

In the botanical division, interesting observations have been made on the distribution of the asparagus rust in Massachusetts and the relation existing between its outbreaks and the rainfall, together with the physical properties of the soil. There is a marked susceptibility of plants

to this disease when grown in soil possessing little water-retaining properties, and a strong relation appears to exist between dry seasons and the occurrence of the summer or injurious stage of the rust.

The chemical division (foods and feeding) has analyzed during the year 2,045 substances, besides carrying on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

The chemical division (fertilizers) has issued 67 licenses to manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals, 38 of whom had offices of general distribution in Massachusetts; 384 samples of fertilizers were collected in the open markets by experienced assistants of the station, and 362 were analyzed and the results published in bulletins.

Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1899.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,216 31	
for labor,	5,167 16	
for publications,	1,090 45	
for postage and stationery,	242 31	
for freight and express,	122 39	
for heat, light and water,	164 77	
for chemical supplies,	3 45	
for seeds, plants and sundry supplies,	484 58	
for fertilizers,	1,076 40	
for feeding stuffs,	208 55	
for library,	411 65	
for tools, implements and machinery,	718 80	
for furniture and fixtures,	61 45	
for scientific apparatus,	201 90	
for live stock,	95 00	
for traveling expenses,	105 21	
for contingent expenses,	139 25	
for building and repairs,	490 37	
		$15,000 00
Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,585 00	
from farm products,	1,641 78	
from miscellaneous sources,	1,906 71	
		$18,333 49
Cash paid for salaries,	$8,127 13	
for labor,	4,275 48	
for publications,	204 00	
for postage and stationery,	211 49	
for freight and express,	162 01	
for heat, light and water,	583 59	
Amount carried forward,	$13,563 70	

Amount brought forward,	$13,563 70	
Cash paid for chemical supplies,	842 90	
for seeds, plants and sundry supplies,	752 76	
for fertilizers,	302 21	
for feeding stuffs,	443 36	
for library,	33 97	
for tools, implements and machinery,	32 75	
for furniture and fixtures,	227 68	
for scientific apparatus,	108 27	
for live stock,	87 22	
for traveling expenses,	272 70	
for contingent expenses,	180 00	
for building and repairs,	1,485 97	
		$18,333 49

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1899; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,333.49, and the corresponding disbursements $33,333.49. All the proper vouchers are on file, and have by me been examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1899.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 11, 1899.

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural department of the station has been more extensive during the past year than ever before during its history. Besides the investigations selected for full discussion later in this report, we have carried on a large number of other out-door experiments, among which may be mentioned those having the following objects in view: with potatoes, to determine the best distance for planting; with oats, to determine relative value of equal money's worth of five different phosphates; with corn, to determine relative value of ten leading phosphates when used in quantities furnishing equal amounts of phosphoric acid; with orchard trees, to test the effects of five different systems of manuring; to test the value of employing nitragin for several of the crops of the clover family; to determine the adaptation and value of different grasses, forage and food crops.

We have put up a glass house for use in connection with pot experiments, and have installed a very complete equipment of iron tracks, trucks, pots, etc., for use in such experiments. The house is 23 by 60 feet, and contains six tracks. The track yard adjoining, which is enclosed by fine wire netting, is 28 by 80 feet. It contains seven tracks, on which the trucks carrying the pots stand during good weather, being quickly run into the house in case of rain or storm. It has transfer track, turn-table and an iron water tank. We have partitioned off a room (12 by 30 feet) in the old barn, cemented the floor, and connected the same with the glass house by iron track about 100 feet in length.

This serves as a work room in connection with pot experiments. We have this year carried on experiments with potatoes, onions, soy beans, corn and millet as crops, in which we have used 286 pots. The results are of much value, having assisted toward the solution of a number of important problems; but, as there remains much chemical work to be finished in connection therewith, these experiments cannot be reported at this time. Of the value of this method of experiment, which has so approved itself with European investigators, there can not be the slightest doubt; it will prove a most important adjunct to field work.

We have further carried out a number of experiments in cylinders 4 feet deep and 2 feet in diameter (without bottom), plunged to the rim in the open air and filled with equal amounts of carefully mixed earth. In these experiments we have employed sixty-three such cylinders, dealing with some important problems. This too proves a valuable method of work. Results are not yet sufficiently worked out for publication.

The report will touch in detail only upon experiments the results of which are sufficiently definite to permit practical deductions of value. The report on such experiments follows.

Soil Tests.

Two soil tests have been carried out upon our home grounds during the past season, both in continuation of previous work upon the same ground. The same kinds of fertilizers have been applied to each plot and in the same amounts as last year. In addition, each plot in the first test received an application of slaked lime, at the rate of one ton per acre; in the second test, one-half of each plot received an application of lime at the same rate. The lime was spread evenly early this spring, and harrowed in, both fields having been ploughed the previous fall.

Soil Test with Corn. Amherst.

The past is the eleventh season that the experiment on this field has been in progress. The crops in order of rotation

have been corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, and this year corn once more. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer; three having but a single important manurial element, nitrogen, phosphoric acid and potash, — every year the same; three have received each year two of these elements; one has received all three yearly; and one each has received yearly lime, plaster and farm-yard manure. It will be seen that the greater part of the field has remained either entirely unmanured or has had but a partial manuring, and it will be readily understood that the degree of exhaustion of most of the plots is considerable. The nothing plots produced this year an average of 4.6 bushels of shelled corn per acre and 767.5 pounds stover; and even this figure is somewhat misrepresentative, owing to the fact that after this long period two of the nothing plots which adjoin plots which have been yearly well manured begin to feel the effect of the high fertility of their neighbors, although separated from them by strips three and one-half feet wide.

The Effect of the Fertilizers.

The table shows clearly the marked differences undoubtedly due to the variation now eleven years continued in the fertilizer treatment. The fertilizers wherever employed are applied at the following rates per acre; nitrate of soda, 160 pounds (furnishing nitrogen); dissolved bone-black, 320 pounds (furnishing phosphoric acid); muriate of potash, 160 pounds (furnishing potash); land plaster, 160 pounds; lime, 160 pounds; and cow manure, 5 cords. All plots, it must be remembered, received also an application of lime at the rate of 1 ton per acre, in addition to the materials named in the table.

*South Acre Soil Test, 1899.**

Plot.	FERTILIZERS.	Yield per Acre.		Gain or Loss compared with Nothing Plots, per Acre.	
		Shelled Corn † (Bushels).	Stover † (Pounds).	Shelled Corn (Bushels).	Stover (Pounds).
1	Nitrate of soda,	13.75	1,160	9.87	430
2	Dissolved bone-black,	3.50	620	—.38	—110
3	Nothing,	3.88	730	-	-
4	Muriate of potash,	49.75	2,760	45.50	2,000
5	Lime,	7.25	1,100	2.62	310
6	Nothing,	5.00	820	-	-
7	Manure,	75.88	5,350	70.88	4,530
8	Nitrate of soda and dissolved bone-black.	21.38	1,220	15.50	380
9	Nothing,	5.88	840	-	-
10	Nitrate of soda and muriate of potash.	47.88	2,360	42.75	1,573
11	Dissolved bone-black and muriate of potash.	59.88	3,160	55.50	2,427
12	Nothing,	3.63	680	-	-
13	Plaster,	6.63	990	3.00	310
14	Nitrate of soda, dissolved bone-black and muriate of potash.	72.88	4,450	69.25	3,770

* All plots limed at rate of one ton per acre.

† Both stover and ears were driest upon the plots giving the larger yields, viz., 4, 7, 10, 11 and 12, for only on these was growth sufficiently normal to allow natural ripening.

The Results in 1898.

[No lime had been used except on the lime plot.]

For purposes of comparison I here present a statement covering the results of last year (1898), when also the crop, as has been pointed out, was corn. I quote from my last annual report: —

The single-element plots, one receiving nitrate of soda only yearly, another phosphoric acid and the third potash, give this year practically equal crops of grain, respectively at the rate of 20.6, 18.5 and 19.8 bushels per acre. The nitrate of soda and dissolved bone-black give a crop at the rate of 32 bushels per acre, while nitrate of soda and potash give at the rate of but 10.9 bushels. The dissolved bone-black and muriate of potash do much better, yielding at the rate of 41.2 bushels. The fertilizer supplying nitrogen, phosphoric acid and potash gives a crop of 55.9 bushels, while manure gives 67.7 bushels.

It may be remembered that in each of the three previous years in which this field has produced corn the muriate of potash has, whether singly or in combination, proved much more useful than either of the other fertilizers used. There is much evidence in the behavior of the crops this year, during the growing season, and in the results, that this salt is proving injurious in its chemical effect upon the soil. I believe this effect to be a loss of lime in the form of chloride by leaching, but cannot regard this as yet proven. I will present the facts apparently bearing upon the case, and leave full discussion to a later report.

1. During the early part of the growing season the corn upon all the plots which had received muriate of potash was distinctly behind that upon other plots.

2. As the season advanced, the corn upon these plots gradually lost its sickly appearance, gained upon that in the other plots, eventually excelling, in the case of the plot receiving nitrogen, phosphoric acid and potash, that in all other plots except the manure plot.

3. This unhealthy appearance of the corn early in the season, followed by great improvement later, is analogous to effects noticed in other experiments,* where chlorides have been used, and where liming the land has remedied the faulty condition.

4. On that plot receiving dissolved bone-black as well as muriate of potash, the crop was in the end a good one. As is well known, the dissolved bone-black contains a large amount of sulfate of lime. It is believed that this may take the place of the lime leached from the soil as a consequence of the use of muriate of potash, or at least that it corrects in some way the faulty condition consequent upon the use of this salt. It may here be pointed out that a similar corrective influence is evident in the results obtained both in 1897 and 1898 upon our other soil test acre, which will immediately be discussed.

It is of interest, further, to point out that the crop this year upon the lime plot was not quite equal to the average of the nothing plots, while that of the plaster plot (sulfate of lime) was about double that of the lime plot. In the earlier years of this soil test the yield of neither the lime nor the plaster plot ever exceeded that of the nothings, but for the past three years the plaster plot has been relatively gaining. The explanation of this difference between the effect of plaster and lime is not apparent. It will be made the subject of future study. . . .

The problems suggested by the results of the year must be

* For example, Plot 6, Field A. See report State Experiment Station for 1896.

regarded as the most valuable product of this experiment. These problems are not solved. Their solution will throw important light upon methods to be employed in compounding and selecting fertilizers.

Conclusions (based upon Results in 1899).

1. By reference now to the table showing the yields for 1899, it will be seen that what last year was merely a suspicion, supported, it is true, by incidental observations in connection with other experiments, is apparently confirmed by the results of this year after liming, viz.: *that last year the application of potash failed to prove beneficial as in the earlier years when corn was grown, because its continued use in the form of muriate had resulted in depleting the soil of its lime.*

It should be noticed that I say "*apparently* confirmed." I would point out that the results of this experiment by themselves do not furnish absolute proof, for its plan is such that it does not enable us to decide that the superior results of the past season may not have been due to the fact that the lime proved beneficial through indirect effects which might have been exerted equally well by some other alkali, such as an alkaline salt of soda or of magnesia. To determine this point, two series of pot experiments with soil from two plots in this field have been carried out. In these, besides slaked lime, we have employed land plaster (sulfate of lime), carbonate and sulfate of magnesia, and bicarbonate and sulfate of soda. The results are not fully worked up, but they decisively indicate: (*a*) *That the benefit from the use of lime was not due to the fact that it corrected soil acidity.* (Sulfate of lime, a neutral salt, produced a better growth than slaked lime, while neither the carbonate of magnesia nor the carbonate of soda proved distinctly beneficial; the latter, indeed, was highly injurious.) (*b*) That it was not due to indirect action of any other sort. (Substances exercising similar chemical and physical influence upon the soil did not prove equally beneficial with the plaster or the slaked lime.)

2. The yield of each of the plots which has been manured with muriate of potash is largely increased. Alone and in

every combination it proves highly beneficial. *That this soil after eleven years' continuous application of muriate of potash at the rate of 160 pounds per acre annually should be capable after liming of producing corn at the rate of 49.75 bushels of shelled grain per acre, is astonishing.*

3. The crop, amounting to almost 60 bushels shelled corn per acre, on the plot which now for eleven years has yearly received only dissolved bone-black and muriate of potash (lime this year of course excepted) and which in this long period of time has received no addition of nitrogen in the form of manure or fertilizers, illustrates the remarkable extent to which, in our climate, the corn plant can thrive upon the natural stores of this element in the soil and that which it accumulates as a result of the introduction of clover into the rotation.

4. It will be noticed that where the elements nitrogen, phosphoric acid and potash have been yearly supplied, the crop this year, amounting to about 73 bushels per acre, is within three bushels of that produced where manure at the rate of 5 cords per acre has been annually applied. The fertilizers used (nitrate of soda, 160 pounds; dissolved bone-black, 320 pounds; and muriate of potash, 160 pounds per acre) cost about $10; while the manure, if purchased, would cost $25 at least in most parts of the State. It should be pointed out, however, that this soil has almost perfect physical characteristics. On the one hand, its perfect drainage insures freedom from excessive moisture even in wet seasons; and, on the other, the happy mean existing in the proportion of fine and coarse particles insures good water-conducting power (capillarity), and thus prevents injury from drought and injurious crust formation. In such a soil the organic matter furnished by manure is far less necessary than in those which are either more sandy or more clayey. For these reasons, fertilizers have doubtless made a more favorable showing as compared with manure than would usually be the case. The table shows the relative standing of the two plots, 7 (manure) and 14 (complete fertilizer), for the entire period of eleven years. It will be seen that the financial outcome where the fertilizer has been used is much better than for the plot receiving manure.

Increases as compared with Plot receiving no Manure.

Produced by Complete Fertilizer, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn,	5	198.05	stover, 12,475	$107 29	$48 00
Oats,	1	15.63	straw, 1,720	14 70	9 60
Rye,	1	15.36	straw, 2,480	12 10	9 60
Soy beans,	1	–	beans, 880; straw, 840	4 61	9 60
Grass,	2	–	hay, 3,420; rowen, 1,360	37 56	19 20
Mustard,	1	–	5,100	–	19 20*
				$176 20	$115 20

Produced by Manure, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn,	5	216.08	stover, 13,990	$117 79	$125 00
Oats,	1	18.13	straw, 3,260	22 11	25 00
Rye,	1	21.07	straw, 3,200	31 84	25 00
Soy beans,	1	–	beans, 1,520; straw, 3,880	77 26	25 00
Grass,	2	–	hay, 4,860; rowen, 3,460	64 27	50 00
Mustard,	1	–	8,500	–	50 00*
				$313 27	$300 00

* Double application of fertilizers and manure for mustard.

Soil Test with Onions. Amherst.

This experiment occupied a field which has been employed in work of this kind for ten years, the several plots having been every year manured alike, as described under the "Soil test with corn." The previous crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes and onions. The land was ploughed in the fall of 1898 and reploughed early this past spring. Fertilizers were employed this year in the same quantities as last, viz., nitrate of soda at the rate of 320 pounds; dissolved bone-black, 640 pounds; and muriate of potash, 320 pounds, per acre. These fertilizers are each used upon one plot singly, in pairs, and upon one plot all three together. The west half of each plot was limed, as has been stated, at the rate of 1 ton per acre.

The seed was sown in the customary manner, but more thickly, on April 28. Germination was prompt and perfect.

The development upon the several plots and upon the unlimed and limed sections of all the plots exhibited the most remarkable differences.

1. Many of the plants upon the nothing plots soon died, and those remaining made practically no growth. The limed halves of these plots throughout the first half of the season were even worse in these respects than the unlimed.

2. The application of no single element without lime gave a good growth; but the plants upon the dissolved bone-black (without lime) did best. With lime the growth was more feeble than without it on the dissolved bone-black plot. On the plot on which muriate of potash was used without lime most of the plants soon died, while on this fertilizer alone and lime there was a rank growth, though few ripe bulbs were harvested. Nitrate of soda with lime gave better growth than without, but both with and without growth was very feeble.

3. On nitrate of soda and muriate of potash without lime almost all plants died; with lime there was a rank growth; but the bulbs did not ripen well.

4. On nitrate of soda and dissolved bone-black without lime was the best growth on the unlimed portion of the field. As last year, the development upon these two fertilizers alone was much better than on the plot where they were employed in the same amounts with muriate of potash. The growth upon the limed portion of the plot receiving the nitrate and bone-black was not materially improved, while where the muriate of potash was used with these fertilizers liming influenced the growth most favorably.

5. Liming proved highly favorable on the plot where dissolved bone-black and muriate of potash were used, this portion of that plot ranking third in the field in appearance throughout the season, while there was little growth upon the unlimed portion.

The Effect of the Fertilizers.

The tables give the results of the harvest: —

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Pounds, including Tops.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed.	Limed.	Unlimed.	Limed.
Plot 1,	Nothing,	2,950	3,180	-	-
Plot 2,	Nitrate of soda,	4,470	9,700	356.67	5,046.67
Plot 3,	Dissolved bone-black,	2,950	2,570	—2,323.33	—2,836.67
Plot 4,	Nothing,	6,440	6,520	-	-
Plot 5,	Muriate of potash,	3,270	24,740	—2,510	18,467.50
Plot 6,	Nitrate of soda and dissolved bone-black.	17,410	17,380	12,290	11,355
Plot 7,	Nitrate of soda and muriate of potash.	1,440	25,030	—3,020	19,252.50
Plot 8,	Nothing,	3,800	5,530	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	11,090	19,510	7,680	13,815
Plot 10,	Nitrate of soda, dissolved bone-black and muriate of potash.	13,770	22,730	10,750	16,870
Plot 11,	Plaster,	1,550	1,610	—1,080	—4,415
Plot 12,	Nothing,	2,240	6,190	-	-

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Bushels of 52 Pounds of fairly cured Onions.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed	Limed.	Unlimed.	Limed.
Plot 1,	Nothing,	2.69	4.42	-	-
Plot 2,	Nitrate of soda,	18.65	91.43	15.13	79.77
Plot 3,	Dissolved bone-black,	6.53	12.31	2.17	—6.60
Plot 4,	Nothing,	5.19	26.15	-	-
Plot 5,	Muriate of potash,	3.07	161.75	—1.54	137.90
Plot 6,	Nitrate of soda and dissolved bone-black.	143.10	200.00	139.06	178.46
Plot 7,	Nitrate of soda and muriate of potash.	3.07	145.40	—.39	121.55
Plot 8,	Nothing,	2.88	16.93	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	40.38	183.88	37.21	163.50
Plot 10,	Nitrate of soda, dissolved bone black and muriate of potash.	46.15	224.60	42.69	200.94
Plot 11,	Plaster,	4.04	6.35	.29	—20.68
Plot 12,	Nothing,	4.04	30.39	-	-

The Results and Conclusions based thereon in 1898.

In 1898 also the crop upon this field was onions, and it is desirable to present the leading statements and conclusions published that year for the purpose of comparison. The manuring was the same as this year, save that no lime was used. I quote from my last annual report: —

The results show that this [phosphoric acid, — dissolved bone-black] more than either the nitrogen or the potash supply controlled the product. The crop was very light, however, even upon the best plot, which was at the rate of 116.9 bushels per acre, upon the plot receiving nitrate of soda and dissolved bone-black. Upon the plots receiving these two fertilizers and muriate of potash the crop amounted to only 16.3 bushels per acre. Here is strong evidence that the muriate of potash has produced in the soil of this field conditions absolutely prejudicial to the growth of the onion.

Last year this field was in potatoes under the same system of manuring, but with half the quantities employed this year. The crop of potatoes on the nitrate and bone-black was much heavier than on these two and potash, and in commenting upon this fact in my annual report I wrote: "The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which these two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must, therefore, conclude that some disturbing factor, at present unknown, influenced the results."

In view of the similar relative results upon the two plots under discussion this year, I am now forced to conclude that I was mistaken last year in supposing that the superiority of the plot receiving nitrogen and phosphoric acid only was not "the effect of the fertilizer alone."

I now believe that the muriate of potash has proved actually injurious to the last two crops, and that the explanation (the loss of lime which it causes) already suggested accounts for this effect.

Conclusions (based upon Results in 1899).

1. A study of the tables giving the results of this year affords convincing presumptive evidence that the continued use of muriate of potash has so depleted this soil of lime that its use for the onion crop is a necessity. The suspicion of last year, just quoted, is apparently confirmed. The results obtained in two series of pot experiments (not yet fully worked up), in which soil from two plots in this field was used, force me, however, to look upon this conclusion as in a measure tentative; for in the pot experiments other alkalies proved almost, if not quite, as beneficial as lime, indicating that the presence of free acid in the soil may have been the cause of the poor growth upon most of the plots of this field. Even this conclusion cannot, however, be looked upon as final, for the substitution of sulfate for the muriate of potash in the pots resulted in good growth without the addition of any alkali. A full discussion of the subject is reserved for some future article.

2. We are meanwhile justified in the statement that both field and pot experiments show that the muriate is an undesirable form in which to apply potash for this crop, though the bad influence of the chlorine which it contains may possibly be neutralized by application of lime.*

3. The remarks of last year may in conclusion be appropriately quoted: —

The Proper Course as regards Potash Supply.

What, then, in view of our results, are we to recommend? Clearly not to cease using potash, — we have been unable to raise good crops without it. It is believed the remedy will be found in one of three directions, viz., (1) the occasional liberal use of lime where muriate of potash is employed; (2) the use of other potash salts, such as carbonate or sulfate; or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulfate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, sup-

* It is believed that the influence of the lime will be even more marked another year. It was applied, it will be remembered, this spring. Its action, as was anticipated, was not sufficiently prompt to prevent much injury to the onions, because of faulty soil conditions in the early part of the season. We have accordingly failed to produce a good yield on any plot this year.

ply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

Manure Alone v. Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a smaller application of manure used in connection with muriate of potash was begun in 1890. A full account will be found in the annual reports of 1890–96, and in 1895 a general summary of the results up to that date was given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn of 1896. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash was used in 1897. The field was kept in grass two years, and was manured as usual in 1898. It includes four plots, of one-fourth an acre each. The average results while in grass are shown below : —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96) : per acre, hay, 5,662 pounds ; rowen, 3,218 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92 ; 4 cords, 1893–96 ; and potash, 160 pounds per acre) : per acre, hay, 4,540 pounds ; rowen, 2,633 pounds.

The sod was turned in the autumn of 1898 and was manured this spring, as shown below : —

Plot 1, manure, 1½ cord ; weight, 8,825 pounds.

Plot 2, { manure, 1 cord ; weight, 5,880 pounds.
high-grade sulfate of potash, 40 pounds.

Plot 3, manure, 1½ cord ; weight, 8,840 pounds.

Plot 4, { manure, 1 cord ; weight, 5,880 pounds.
high-grade sulfate of potash, 40 pounds.

The crop this year has been corn (Sibley's Pride of the North), and its development appears to have been normal in all respects. The crop was a heavy one on all plots.

Yield per Plot.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1, ...	1,331	1,260
Plot 2, ...	1,331	1,160
Plot 3, ...	1,341	1,170
Plot 4, ...	1,355	1,110

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone), ...	66.8	4,860
Plots 2 and 4 (manure and potash), ...	67.2	4,540

It will be noticed that the crops are of practically equal value, — a little more grain on the manure and potash and a little more stover on the larger quantity of manure alone. The manure and potash used cost per acre nearly $7 less than the larger amount of manure used alone.

We have now grown seven corn crops on this field, and the average yields are at the rate per acre for the two manurings : —

Average of Seven Crops.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Manure alone, ...	61.5	4,562
Lesser manure and potash, ...	56.7	4,168

At prices which have prevailed during the period covered by this experiment the total manurial application where the manure and potash have been used has cost at the rate of $75 per acre less than on the other plots. The manure alone, however, has produced yields excelling the lesser manure and potash for the entire period at rates per acre amounting to: shelled corn, 33.6 bushels; corn stover,

2,758 pounds ; hay, 2,244 pounds ; and rowen, 1,170 pounds. These products would have been worth $46.50. In using the large amount of manure alone, then, one would in effect, allowing the manure to cost $5 per cord on the land, have expended $75 for products worth but little more than one-half that sum.

When, further, we note that at present the lesser manure and potash is producing the larger crop of grain, the superior economy of the system is evident.

"Special" Corn Fertilizer *v.* Fertilizer richer in Potash.

This experiment was begun with a view to comparing the results obtained with a fertilizer proportioned like the average "*special*" *corn fertilizers* found upon the markets in 1891 with those obtained with a fertilizer richer in potash, but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots, if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots, of one-fourth of an acre each. The materials supplied to the several plots are shown in the following table : —

FERTILIZERS.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	20.0	18.0
Dried blood,	30.0	30.0
Dry ground fish,	30.0	20.0
Plain superphosphate,	226.0	120.0
Muriate of potash,	22.5	60.0
Cost of materials per plot,	$3 23	$3 10

The field was kept in grass for two years, the average yields being at the rates per acre : " Special " fertilizer : hay, 2,730 pounds ; rowen, 1,122 ; fertilizer richer in potash : hay, 2,557.5 pounds ; rowen, 1,149 pounds. The "special," it will be seen, gave yearly 172.5 pounds more hay but 27 pounds less rowen than the other fertilizer. The larger nitrogen application accounts for the excess in hay ; the larger potash application to the other plot produces the more rowen. The stand of clover in the field was poor. It is believed that, had it been good, the differences in yield of rowen in favor of the fertilizer richer in potash would have been larger.

The sod was ploughed in the autumn of last year, fertilizers as usual applied and wheel-harrowed in this spring. The crop this year was corn, which made perfectly normal and good growth on all plots and gave a good yield.

Yield of Corn, 1899.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1 (lesser potash),	1,257.5	1,090
Plot 2 (richer in potash),	1,141.0	1,140
Plot 3 (lesser potash),	1,168.5	1,120
Plot 4 (richer in potash),	1,200.5	1,120

Average Rates per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3,	60.7	4,420
Plots 2 and 4,	58.5	4,520

The crops this year are almost equal, — the "special" giving a little more than 2 bushels more grain ; the fertilizer, richer in potash, 100 pounds more stover. The former gives somewhat the more valuable and the more profitable crop. The advantage, however, is insignificant, amounting to only 25 cents per acre.

The experiment has now been in progress nine years, and during seven of these years corn has been grown; on all plots five years and on two only of the plots two years. The averages for the seven years are given in the table: —

Average Yield Corn, Seven Years.

	Shelled Grain (Bushels per Acre).	Stover (Pounds per Acre).
"Special" fertilizer,	57.95	3,760
Fertilizer richer in potash,	50.41	4,033

During two years one-half this field was occupied by Japanese millet (*Panicum Italicum*). The average yields per year are shown in the table: —

Averages, Millet, Two Years.

	Millet Seed (Bushels per Acre).	Straw (Pounds per Acre).
"Special" fertilizer,	63.15	3,522
Fertilizer richer in potash,	66.55	3,735

It will be seen, then, that thus far the two systems of manuring stand nearly upon an equality. The fertilizer poorer in potash ("special") has given the more corn and the more hay. The other fertilizer, richer in potash, has given the more corn stover, rowen, millet seed and millet straw. At present the two stand practically equal, as shown by the corn crop of the past season, It is believed that by the frequent introduction of clover (of which we have not yet had a good catch) the fertilizer richer in potash will prove superior to the other.

Sulfate compared with Muriate of Potash for Various Crops. (Field B.)

This experiment has been in progress in its present essential features since 1893. From 1884 to 1889 the odd numbered plots, 11 to 21, were manured yearly at the rate of 200 pounds per acre of muriate of potash, while the even

numbered plots received no potash. From 1889 to 1892 all plots were manured alike. Since 1892 each plot has received yearly bone meal at the rate of 600 pounds per acre, the odd numbered plots muriate of potash at the rate of 400 pounds, and the even numbered plots high-grade sulfate of potash at the same rate per acre. There are eleven plots, numbered 11 to 21. These plots have been used for a wide variety of crops during the seven years that the experiment has been continued. The crops during the past year have been sugar beets, sweet corn, cabbages, field corn and soy beans.

Sugar Beets (Sulfate v. Muriate of Potash).

Sugar beets of four varieties occupied plots 15 and 16. The yield on 15 (muriate of potash) amounted to 3,815 pounds (14.3 tons) per acre; the yield on 16 (sulfate of potash) amounted to 3,708 pounds (13.9 tons) per acre. Each variety was sampled and the value of the beets for sugar manufacture determined. With one exception the beets grown on the sulfate of potash showed considerably higher percentages of sugar and a juice of a higher degree of purity than those grown on the muriate. Though the latter gave a slightly higher yield, the sulfate produced more sugar and a juice offering less difficulties in manufacture. In the case of the one variety where the muriate gave the richer beet, it is believed that this was due to the fact that the sulfate beets selected for analysis were considerably larger than the others. The differences in quality between the beets grown on the two salts were not sufficiently great to materially affect their value for stock feeding.

Sweet Corn (Sulfate v. Muriate of Potash).

This crop (Moore's Concord) occupied plots 11 and 12. Our objects were: first, to study the effect of the two forms of potash on yield; second, to determine whether there was any difference in quality between the product of the two plots which would affect its value for the table; and, third, to determine whether there was any well-defined difference in composition of the entire plant (stalk and ear) which would affect the value for stock feeding.

1. *Product.* — The details concerning product are shown in the table : —

Sweet Corn.

	Weight of Entire Crop (Pounds).	Number of Ears.		Total Ears (Pounds).	Weight of Stover (Pounds).
		Large.	Small.		
Muriate of potash, . .	4,965	1,411	335	929.69	4,035.31
Sulfate of potash, . .	4,965	1,574	377	1,034.36	3,930.64

In the judgment of the men handling the crop, the plants stood slightly thicker on plot 12 than on plot 11, and it is likely that this accounts in large measure, if not entirely, for the greater number of ears on plot 12. It will be noticed that the total product was the same on the two plots.

2. *Quality for Table Use.* — Chemical examination of kernels of corn from the two plots showed no difference which can be regarded as significant ; in fact, the differences are probably within the limits of error. It therefore appears that the chlorine of muriate did not exert the depressing effect on sugar formation that is often noticed with other crops.

3. *The Food Value of the Entire Plant.* — Analyses of the product of the two plots revealed no differences in composition which would materially affect the feeding value.

Field Corn (Eureka for the Silo) (Sulfate v. Muriate of Potash).

This crop occupied plots 19 and 20, and on both made a fine growth, averaging 15 feet in height. The ears were small and in the milk when the crop was ensiled, September 28. The yields (obtained by weighing after partial wilting) were : —

Muriate plot, 6,145 pounds, at rate of 23 tons per acre.

Sulfate plot, 5,675 pounds, at rate of 21.2 tons per acre.

Feeding Value. — The crop from both plots was sampled for analysis. The results showed no important differences in the feeding value of the product on the two salts.

Maercker* has quoted Moser to the effect that corn raised on muriate of potash contains more protein, and therefore has a higher food value, than when grown on sulfate. Three experiments here, one in 1898 and the two this year, have not shown this to be the case. It would appear that the muriate of potash is equally as good for the corn crop as the sulfate.

Soy Beans (*Sulfate v. Muriate of Potash*).

Through accident the product of the soy bean plots was mixed; and I can only report that during the early part of the season the beans on the sulfate appeared much better than the others. Later this apparent superiority was lost in large measure, as judged after careful examination.

Cabbages (*Sulfate v. Muriate of Potash*).

This crop (Warren cabbage) occupied plots 13 and 14. The growth on the sulfate of potash was from the start much better than on the muriate, and this superiority was maintained throughout the season. The yield is shown in the table:—

	Number of Hard Heads, November 2.	Total Weight (Pounds).		Loose Leaves (Pounds).
		Hard Heads.	Soft Heads.	
Muriate of potash, . .	393	4,105	720	750
Sulfate of potash, . .	502	5,475	255	1,060

It will be noticed that the sulfate of potash plot gave much the larger and more valuable crop. It should be pointed out that, on account of difference of growth due to accidental conditions, the above table has been made to include the yield for only about one-ninth of an acre. The product of plot 14 sold at a price (5 cents per head) which would have made the product of one acre of such cabbages worth about $250, while the product of the other plot was worth only at the rate of about $200 per acre.

* Die Kalidungung, p. 252.

Comparison of Different Potash Salts. (Field G.)

The object in this experiment is to determine the relative manurial value for our various crops of the different prominent potash salts. The experiment was begun in 1898, the crop that year being the soy bean. The results were indecisive and unsatisfactory, the crop where no potash was used in numerous instances being as great as where potash manures were applied. The potash resources of the soil were clearly too large to allow satisfactory deductions to be made. This had, however, been anticipated. From the nature of the problem it was recognized that the experiment must continue for a series of years. We must study not simply the immediate effect upon the crop, but the effect upon the soil of long-continued use of the different salts, — and as well the effect upon the crop of such continued use.

In this experiment the plots are one-fortieth of an acre each, duly separated by dividing strips. There are forty plots, each manuring being five times duplicated. Every plot receives yearly materials estimated to furnish nitrogen and phosphoric acid in liberal amounts. All receive the same materials, save plots 6, 14, 22, 30 and 38, on which the potash salt used is the nitrate, so that the amount of nitrate of soda for these is made only sufficient (.5 pounds) to furnish to these plots the same amount of nitrate nitrogen as to the others. With this exception, the materials applied as sources of nitrogen and phosphoric acid are, per plot: —

	Pounds.
Nitrate of soda,	7.0
Tankage,	7.5
Acid phosphate,	10.0

In order to make certain that there should be no failure through deficiency of lime, the entire field received an application at the rate of one ton to the acre of lime freshly slacked, which was wheel-harrowed in early in the spring of 1898.

The various potash salts where used were applied in amounts intended to furnish an equal quantity of actual potash (K_2O) to each plot, as follows: —

		Pounds.
Plot 1.	No potash.	
Plot 2.	Kainite,	27.75
Plot 3.	High-grade sulfate of potash,	7.50
Plot 4.	Low-grade sulfate of potash,	15.00
Plot 5.	Muriate of potash,	7.50
Plot 6.	Nitrate of potash,	8.25
Plot 7.	Carbonate of potash-magnesia,	20.00
Plot 8.	Silicate of potash,	17.00

Plots 9–16, 17–24, 25–32 and 33–40 are duplicates respectively of plots 1–8.

The crop this year (the second of the experiment) was potatoes, Beauty of Hebron, seed from Maine. It was planted in drills, one set (2–3 eyes) in 14 inches. The tubers were subjected to the formalin treatment, to prevent scab, being soaked two hours in a solution of eight ounces to 15 gallons of water. They were budded in a light room after treatment, before being planted on May 8–9. The crop was well cared for, and sprayed repeatedly with Bordeaux mixture, to prevent blight, of which there was little. The yield was heavy, varying from 297 to 380 bushels of merchantable potatoes per acre on the different potash salts. The results are not entirely conclusive, for the reason that in duplicate plots the yields of the different salts do not occupy the same relative rank. Thus, for example, the various salts made the following relative yields in merchantable tubers : —

Kainite stands : —
1st, once ; 3d, once ; 6th, twice ; and 7th, once.
High-grade sulfate of potash stands : —
1st, twice ; 2d, twice ; and 3d, once.
Low-grade sulfate of potash stands : —
2d, twice ; 3d, once ; 6th, once ; and 7th, once.
Muriate of potash stands : —
1st, once ; 4th, twice ; 5th, once ; and 6th, once.
Nitrate of potash stands : —
Once each : 3d, 4th, 5th, 6th and 7th.
Carbonate of potash-magnesia stands : —
1st, twice ; 3d, twice ; and 5th, once.
Silicate of potash stands : —
4th, twice ; 6th, twice ; and 7th, once.

With such variations in relative standing, it will be agreed we must interpret results with caution. Still, it is believed that the average yield of the different salts should be published as a matter of record: —

Average Yield of Plots.

PLOTS.	Pounds per Plot.		Bushels per Acre.	
	Large.*	Small.	Large.*	Small.
No potash,	430.70	61.00	287.13	40.66
Kainite,	488.45	52.60	326.83	33.86
High-grade sulfate,	525.70	52.95	350.46	35.49
Low-grade sulfate,	508.20	55.70	338.79	37.13
Muriate,	506.30	61.40	337.53	40.93
Nitrate,	498.20	64.75	332.13	43.16
Carbonate,	518.00	64.80	345.33	43.39
Silicate,	492.40	56.00	328.26	38.39

* Two ounces or over.

Conclusions.

1. It will be noticed that the soil is potash hungry, for every one of the salts used increases the yield.

2. The high-grade sulfate of potash stands first. It has with rare exceptions been found more effective in increasing the yield than the muriate, with which it has been frequently compared, and it gives better quality. We are justified in the conclusion that the application of potash in this form for the potato will give good results. It should be pointed out that our soil is moderately heavy and retentive. On drier sorts the muriate may compare with the sulfate more favorably.

3. The comparatively new carbonate of potash-magnesia ranks second. It is as carbonate that potash exists in wood ashes, which, however, are believed to favor some forms of scab. The fertilizer did not have that effect. This appears to be, then, a very useful form of potash. In mechanical condition it leaves nothing to be desired, being fine and remaining dry under all conditions of weather. The price is at present too high to allow its general use.

4. The low-grade sulfate of potash ranks third; but, as freights cost more per unit of potash for this salt than for the high grade, the latter is generally to be preferred. It is not impossible that in some localities the magnesia of the low-grade sulfate may prove useful; but we have no evidence that such is the case here.

5. The kainite ranks lowest among all the salts employed. Since this, containing only about 13 per cent. of actual potash, can be purchased at a much lower ton price than the purer salts, such as the high-grade sulfate and the muriate, it is sometimes selected by farmers. It should be remembered that the unit of potash on the farm usually costs more in the kainite than in the others. In view of our results, then, I can see no reason for selecting this potash fertilizer.

6. The silicate of potash gives the next lowest crop. It is apparently slowly available. The present cost is high, and it can be kept from caking only by admixture with powdered peat or similar material. It is prepared especially for use on tobacco, for which crop it is under trial in Germany and in this country. I judge it will have no application for ordinary crops; and its usefulness for tobacco is not fully demonstrated, though some favorable results have been obtained.

Leguminous Crops (Clover, Pea and Bean or "Pod" Family) as Nitrogen Gatherers. (Field A.)

This experiment is a continuation of a series begun in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulfate of ammonia, dried blood and farm-yard manure as sources of nitrogen.*

The plots, eleven in number, are one-tenth acre each, and are numbered 0 to 10. Three plots (4, 7 and 9) have re-

* Only such details are given here as are necessary to an understanding of the nature of the experiment. Full particulars will be found in our ninth and tenth annual reports.

ceived no nitrogen-containing manure or fertilizers since 1884; one (0) has received farm-yard manure; two (1 and 2), nitrate of soda; three (5, 6 and 8), sulfate of ammonia; and two (3 and 10), dried blood every year since 1889. These materials have been used in amounts to furnish nitrogen at the rate of 45 pounds per acre each year.

All plots have received yearly equal quantities of phosphoric acid and potash; viz., 80 pounds per acre of the former and 125 pounds of the latter from 1889 to 1894 and the past four seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulfate; to others, in the form of muriate. The results with the former salt have been superior to those with the latter, as a rule, particularly when used in connection with sulfate of ammonia. The entire field received at the rate of 1 ton per acre of partially air-slacked lime in the spring of 1898, in addition to the usual fertilizers.

Up to this year we may briefly characterize the results, in so far as these have a bearing upon the two main questions proposed, as follows: —

1. The leguminous crops grown (soy beans in 1892, 1894 and 1896) have not appeared to enrich the soil in nitrogen, if we accept the results with the next following crop as affording a basis of judgment.

2. The different sources of nitrogen have ranked on the average in the following order: nitrate of soda, farm-yard manure, dried blood and sulfate of ammonia.

The crop in 1898 was oats. After harvesting them, the land was ploughed and sown to what was supposed to be mammoth red clover in August. The variety appears to be the common red. This went into the winter in excellent condition, but was somewhat winter-killed on all plots, apparently for reasons unconnected with the manures which had been employed. The injury was most severe on plots 0, 5 and 8, and least on plot 5. Between the other plots there was little difference in the degree of injury, if we except plot 6, on which it was greater than on the others. Seed was sown on the surface this spring where needed. This germinated well, but the young plants made little growth, on account of the dry weather. Two crops were

cut, the first on July 3. The plants at this time had ceased growth, on account of drought. Not all had blossomed, yet the condition must be classed as mature. The yield was seriously decreased by the dry weather. The second crop was cut August 21, being somewhat mixed with annual grasses, but apparently to equal degree in all plots. The hay was secured in good condition, being cured mostly in the cock. The table shows the fertilizer treatment and the yields of the several plots: —

Nitrogen Experiment, — Fertilizers used and Yield of Clover.

Plots.	FERTILIZERS.	Pounds.	Clover Hay (Pounds).	Clover Rowen (Pounds).	Total (Pounds).
Plot 0,	Barn-yard manure, . . Potash-magnesia sulfate, . Dissolved bone-black, . .	800.0 32.0 18.0	220.0	288.3	508.3
Plot 1,	Nitrate of soda, ... Potash-magnesia sulfate, . Dissolved bone-black, . .	29.0 48.5 50.0	200.0	243.8	443.8
Plot 2,	Nitrate of soda, ... Potash-magnesia sulfate, . Dissolved bone-black, . .	29.0 48.5 50.0	220.0	202.6	422.6
Plot 3,	Dried blood, ... Muriate of potash, . . . Dissolved bone-black, . .	43.0 25.0 50.0	120.0	225.8	345.8
Plot 4,	Muriate of potash, . . . Dissolved bone-black, . .	25.0 50.0	140.0	196.8	336.8
Plot 5,	Ammonium sulfate, . . Potash-magnesia sulfate, . Dissolved bone-black, . .	22.5 48.5 50.0	140.0	202.1	342.1
Plot 6,	Ammonium sulfate, . . Muriate of potash, . . . Dissolved bone-black, . .	22.5 25.0 50.0	140.0	235.6	375.6
Plot 7,	Muriate of potash, . . . Dissolved bone-black, . .	25.0 50.0	180.0	162.9	342.9
Plot 8,	Ammonium sulfate, . . Muriate of potash, . . . Dissolved bone-black, . .	22.5 25.0 50.0	200.0	207.5	407.5
Plot 9,	Muriate of potash, . . . Dissolved bone-black, . .	25.0 50.0	215.0	206.5	421.5
Plot 10,	Dried blood, ... Potash-magnesia sulfate, . Dissolved bone-black, . .	43.0 48.5 40.0	215.0	241.5	456.5

It is perhaps questionable whether much weight should be attached to the yields at the first cutting, since full development was not reached on account of drought. The rowen gives a better basis for comparison. Studying these figures, we find the following points bearing upon the problem on which the experiment seeks to shed light: —

1. *The various materials furnishing nitrogen rank in the following order: manure, dried blood, nitrate of soda and sulfate of ammonia.*

2. *The plots receiving no nitrogen approach in average yield much more closely to those getting this element than has been the case with any previous crop on this land. This must be regarded as highly significant, for it will be remembered that this field has been under experiment for eleven years, and in all that time these plots have received no nitrogenous manure or fertilizer of any kind. The clover must, it seems evident, have drawn from the air for this element, in which, as is well known, it is especially rich.*

Fertilizers for Garden Crops. (Field C.)

This series of experiments was begun in 1891, and has for its objects to test the relative value for garden crops: (1) of sulfate of ammonia, nitrate of soda and dried blood as sources of nitrogen; and (2) of muriate and sulfate as sources of potash. For full details concerning the methods followed and earlier results, reference is made to my eleventh annual report. It should, however, be pointed out here that partially rotted stable manure has been applied in equal amounts to all the plots for the last two years. The amount of such manure used this year was 7,200 pounds per plot. The fertilizers used were as follows: —

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulfate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulfate of ammonia,	38
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulfate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds. For purposes of comparison, I quote from my last annual report: —

Conclusions based on Results up to 1897. (Fertilizers Alone.)

The chief conclusions which seemed justified by the results with fertilizers alone are the following: —

1. Sulfate of potash in connection with nitrate of soda (plot 5) has generally given the best crop. In those cases where this has not been true, the inferiority of this combination has usually been small. In one case only has it fallen much behind, viz., with sweet corn, a crop which makes much of its growth in the latter part of the season.

2. Nitrate of soda (plots 2 and 5) has in almost every instance proved the most valuable source of nitrogen, whether used with the muriate or the sulfate of potash.

3. The combination of sulfate of ammonia and muriate of potash (plot 1) has in every instance given the poorest crop. This fact is apparently due, as Dr. Goessmann has pointed out, to an interchange of acids and bases leading to the formation of chloride of ammonia, which injuriously affects growth.

The Experiment in 1899.

The crops on each plot this year included the following: fruiting strawberries, celery (following the strawberries), cabbages, squashes, spinach, lettuce, table beets, onions and freshly set strawberries. Both manure and fertilizers were spread on after ploughing this spring and harrowed in.

Strawberries: — The vines of the fruiting beds were set in the spring of 1898. They all made good growth, but were somewhat winter-killed, apparently because covered rather too heavily. The injury was not very materially different on the different plots, but was judged to have been somewhat most serious on plots 0 and 2 and least on plot 4. Picking began on June 15 and ended on July 12. Plot 0 (manure alone) much exceeded the others in yield of ripe fruit at first, and in aggregate yield was excelled by but two of the plots. The total yields in pounds per plot were as follows: plot 0, 126.6 pounds; plot 1, 94.7 pounds; plot

2, 96.6 pounds; plot 3, 155.1 pounds; plot 4, 172.3 pounds; plot 5, 108.1 pounds; plot 6, 103.3 pounds.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (plot 0),	126.6
Average of manure and muriate of potash (plots 1, 2 and 3),	115.4
Average of manure and sulfate of potash (plots, 4, 5 and 6),	128.8
Average of manure and sulfate of ammonia (plots 1 and 4),	161.9
Average of manure and nitrate of soda (plots 2 and 5),	102.3
Average of manure and dried blood (plots 3 and 6),	129.2

It will be noticed that but two of the combinations of fertilizers used with the manure excel the manure alone, viz., sulfate of ammonia and sulfate of potash, and dried blood and muriate of potash. Nitrate of soda, which we have found the best source of nitrogen for most crops, makes the poorest showing. Between the muriate and sulfate of potash there seems to be no clearly defined difference. These results were doubtless in part determined by the degree of winter injury.

Celery. — This crop followed the strawberries without extra manuring. The share of the stable manure belonging to the fruiting strawberry area was, however, applied when the strawberry vines were turned in. The yields of the several plots in pounds were as follows: plot 0, 720.8; plot 1, 250; plot 2, 550; plot 3, 510; plot 4, 190; plot 5, 585; plot 6, 550.

The average yields in pounds produced by the different fertilizers were: —

Manure alone,	720.8
Manure and muriate of potash (plots 1, 2 and 3),	436.7
Manure and sulfate of potash (plots 4, 5 and 6),	441.7
Manure and sulfate of ammonia (plots 1 and 4),	220.0
Manure and nitrate of soda (plots 2 and 5),	567.5
Manure and dried blood (plots 3 and 6),	530.0

* To enable the reader to better make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulfate of potash," etc. It should be remembered that dissolved bone-black was applied to all except plot 0, and that every plot except plot 0 received material supplying both nitrogen and potash as well as phosphoric acid in addition to the manure. For the full list of fertilizers applied to each plot, see page 35.

It will be noted that the manure alone gave much the largest crop.* Discussion as to the effect of the fertilizers, then, hardly seems called for. It is not without interest, however, to note that the crops where sulfate of ammonia was employed were much the smallest in the field. The result last year was similar in this respect.

Hanson Lettuce. — In harvesting this crop the heads of market size were cut from day to day. The total yields per plot in pounds were: plot 0, 83.1; plot 1, 54.75; plot 2, 129.25; plot 3, 150.50; plot 4, 88.5; plot 5, 148; plot 6, 122.25.

The average yields in pounds on the different fertilizers were: —

Manure alone (plot 0),	83.1
Manure and muriate of potash (plots 1, 2 and 3),	111.5
Manure and sulfate of potash (plots 4, 5 and 6),	119.6
Manure and sulfate of ammonia (plots 1 and 4),	71.6
Manure and nitrate of soda (plots 2 and 5),	138.6
Manure and dried blood (plots 3 and 6),	136.4

The sulfate of potash proves somewhat superior to the muriate; but the most marked result is the highly unfavorable influence of the sulfate of ammonia. This, as in previous years, in combination with the muriate of potash acts as a plant poison.

Spinach. — This, like the lettuce, was cut from time to time as it became ready for market. The yields in pounds of the several plots were: plot 0, 83.8; plot 1, 3; plot 2, 36.8; plot 3, 46.5; plot 4, 42; plot 5, 75.25; plot 6, 56.5.

The averages on the several fertilizers in pounds were: —

Manure alone (plot 0),	83.8
Manure and muriate of potash (plots 1, 2 and 3),	28.8
Manure and sulfate of potash (plots 4, 5 and 6),	57.9
Manure and sulfate of ammonia (plots 1 and 4),	22.5
Manure and nitrate of soda (plots 2 and 5),	56.0
Manure and dried blood (plots 3 and 6),	51.5

It is noticeable that manure alone produces a considerably larger crop than manure with any combination of fertilizers.

* In explanation of this fact, it should be pointed out that plot 0 previous to 1898 had entirely different manuring and cropping from the other plots. See last annual report. It is not believed that the fertilizers were injurious, as a rule.

The most marked effect is the injurious influence of the sulfate of ammonia.

Onions. — The yields of the several plots are shown in the table : —

PLOTS.	Well-cured Onions (Pounds).	Well-formed Onions, but not cured (Pounds).	Scallions (Pounds).
Plot 0,	1,334.5	26.5	13.0
Plot 1,	214.8	108.5	108.3
Plot 2,	1,174.0	75.0	24.0
Plot 3,	761.5	184.0	157.0
Plot 4,	632.7	248.5	93.0
Plot 5,	1,415.8	81.0	17.0
Plot 6,	929.3	243.8	79.8

The averages on the several fertilizers were : —

	Merchantable (Pounds).	Green (Pounds).	Scallions (Pounds).
Manure alone (plot 0),	1,334.5	26.5	13.0
Manure and muriate of potash (plots 1, 2 and 3),	716.8	122.5	96.4
Manure and sulfate of potash (plots 4, 5 and 6),	992.6	191.1	63.3
Manure and sulfate of ammonia (plots 1 and 4),	423.7	178.5	100.6
Manure and nitrate of soda (plots 2 and 5),	1,294.9	78.0	20.5
Manure and dried blood (plots 3 and 6),	845.4	213.9	118.9

It becomes evident from these figures (1) that none of the fertilizer combinations except one (nitrate of soda and sulfate of potash) benefited the crop, (2) that the sulfate is much superior to the muriate as a source of potash, and (3) that the nitrate of soda is much the best source of nitrogen.

Table Beets. — With this crop the manure alone gave much the best yields, and the several fertilizer combinations failed to produce effects sufficiently marked to warrant discussion. The details, therefore, will not be given.

Cabbages. — But one plot in this crop gave a yield excelling the manure alone, and that was the one receiving, in addition to manure, sulfate of ammonia and muriate of potash. The yields in hard heads in pounds were as follows :

plot 0, 375.1; plot 1, 420; plot 2, 377.5; plot 3, 337.5; plot 4, 347.5; plot 5, 207.5; plot 6, 320.

The averages on the several fertilizers in pounds were: —

	Hard Heads.	Soft Heads.
Manure alone (plot 0),	375.1	223.9
Manure and muriate of potash (plots 1, 2 and 3),	378.3	29.2
Manure and sulfate of potash (plots 4, 5 and 6),	291.7	29.2
Manure and sulfate of ammonia (plots 1 and 4),	383.7	12.5
Manure and nitrate of soda (plots 2 and 5),	292.5	52.5
Manure and dried blood (plots 3 and 6),	328.6	22.5

So far as results justify conclusions, it would seem (1) that the muriate shows itself superior to the sulfate of potash for this crop *when used with stable manure*, and (2) that the sulfate of ammonia is the best source of nitrogen for it. That the sulfate of ammonia should prove the most useful form of nitrogen supply with a crop making most of its growth in the latter part of the season we have before observed.*

In other experiments with cabbages this year, where fertilizers alone were used, the sulfate of potash gave much larger yields than the muriate.† Here this is reversed. I have at present no explanation to offer for this difference.

Squashes. — This crop gave much the best yield on manure alone, and the differences apparently produced by the several fertilizers are not significant. The sulfate gives larger yields than the muriate of potash in every case, while the sulfate of ammonia makes the lowest showing among the fertilizers supplying nitrogen. The details will not be given.

Variety Tests with Potatoes.

The number of varieties tested this year was 94. The seed used was all of our own raising. It was produced under conditions similar in every respect and had been similarly preserved. Of each variety, with a few exceptions later noted, 80 sets were planted at the distance of 1 foot

* See eleventh annual report. † See page 28.

in drills 3 feet apart. One-half of these were harvested at early market maturity (August 1), the balance at full maturity (September 22–23).

The soil was a medium loam, in mixed grass and clover for the two preceding years. It received an application of farm manure at the rate of about 5 cords per acre on the sod early this spring, and was then ploughed. The fertilizers used in pounds per acre were : —

Nitrate of soda,	240
Acid phosphate,	400
Sulfate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were thoroughly mixed and scattered widely in the open furrow before dropping the seed. The seed potatoes were first washed and then treated in formalin solution (8 ounces to 15 gallons water) for two hours. The tubers were budded in a light room after treatment. The planting was done May 4 and 5. The crop was well cared for, and sprayed six times with Bordeaux mixture, to prevent blight, of which, however, there was considerable. The development was normal, save for the blight; and the yields and quality for the most part good. There was practically no scab.

The tables give data for the earlier and the latter diggings : —

Variety Test Potatoes. Record to Aug. 1, 1899.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.*	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Abundance,	June 23,	July 22,	1/16	148.5	24.3
Acme,	June 23,	July 19,	½	244.0	24.3
Algoma,	June 28,	July 22,	¼	154.5	40.9
American Beauty,	June 17,	July 22,	¼	200.0	10.6
Arizona,	June 17,	July 18,	¼	224.3	51.5
Bartlett,	June 28,	July 24,	1/16	181.8	30.4
Beauty of Hebron,	June 19,	July 24,	⅛	260.6	40.9

* Fractions indicate proportion of foliage destroyed.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	YIELD AT RATE PER ACRE. Large, Two Ounces (Bushels).	Small (Bushels).
Burpee's Superior,	June 23,	July 22,	⅛	236.4	39.4
Burr's No. 1,	June 19,	July 22,	¼	262.1	45.5
Cambridge Russet,	June 23,	July 18,	¼	166.7	24.3
Carmen No. 1,	June 19,	July 22,	⅝	295.5	30.3
Champion of the World,	June 19,	July 22,	⅛	206.1	31.8
Clay Rose,	June 17,	July 18,	¼	239.4	39.4
Commercial,	June 28,	July 22,	¼	209.1	12.1
Country Gentleman,	June 19,	July 22,	⅛	251.5	33.3
Dakota Red,	June 30,	July 18,	½	184.9	27.3
Dreer's Standard,	June 23,	July 22,	¼	272.8	21.2
Dutton's Seedling,	June 19,	July 22,	⅛	298.5	36.4
Early Kansas,	June 19,	July 22,	⅛	298.5	33.3
Beauty of Hebron,	June 19,	July 24,	Trace.	287.9	31.8
Early Minnesota,	June 28,	July 18,	⅜	190.9	27.3
Early Roberts,	June 19,	July 22,	⅜	300.0	63.6
Early Rochester,	June 19,	July 22,	⅜	230.3	15.2
Early Rose,	June 19,	July 18,	½	263.6	51.5
Early Sunrise,	June 19,	July 18,	¼	221.2	51.5
Extra Early Vermont,	June 19,	July 15,	⅜	266.7	42.4
Empire State,	June 28,	July 22,	¼	148.5	24.3
Enormous,	June 19,	July 22,	⅛	275.8	9.1
Everett,	June 19,	July 15,	½	207.6	45.5
Fillbasket,	June 17,	July 20,	1/16	223.0	51.5
Garfield,	June 19,	July 22,	⅛	193.9	33.3
German Queen,	June 19,	July 22,	¼	213.7	24.3
Good Times,	July 6,	July 29,	Trace.	151.5	21.2
Governor Rusk,	June 28,	July 20,	⅜	236.4	9.1
Green Mountain,	June 23,	July 24,	⅛	127.3	18.2
Howard,	June 19,	July 24,	⅛	275.8	33.3
Hurst,	June 28,	July 15,	¾	–	–
Mill's Longkeeper,	June 23,	July 20,	¼	–	–
Irish Cobbler,	June 17,	July 20,	⅜	260.6	30.3
Joseph,	July 6,	July 24,	¼*	169.7	28.8
King of the Earliest,	–	July 22,	⅜	265.2	24.3
King of Roses,	June 19,	July 22,	¼	209.1	54.6
Lakeside Champion,	June 19,	July 20,	⅜	245.5	39.4

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Late Puritan,	June 23,	July 24,	⅛	224.3	48.5
Lee's Favorite,	June 19,	July 22,	¼	278.8	47.0
Leonard Rose,	June 19,	July 20,	¼	239.4	42.4
Lincoln,	June 19,	July 29,	⅛	212.1	37.9
Maule's Thoroughbred,	June 19,	July 22,	3/16	260.6	48.5
Mayflower,	–	July 22,	¼	124.3	42.4
Mill's Banner,	June 23,	July 29,	Trace.	112.1	15.2
Mill's Prize,	June 28,	July 22,	Trace.	154.5	18.2
Money Maker,	June 23,	July 22,	⅛	145.5	12.1
Montana Wonder,	June 17,	July 22,	⅜	260.6	33.3
New Satisfaction,	June 19,	July 22,	¼	190.9	18.2
Parker's Market,	June 23,	July 22,	½	218.2	30.3
Penn Manor,	June 19,	July 22,	⅜	284.9	39.4
Pingree,	June 23,	July 22,	¼	190.9	37.3
Prince Bismark,	June 19,	July 22,	⅜	269.7	21.2
Prize Taker,	June 23,	July 22,	½	244.0	25.8
Early Potentate,	–	July 20,	½	187.9	30.3
Pride of Michigan,	June 19,	July 22,	¼	209.1	50.0
Prolific Rose,	June 19,	July 22,	⅛	257.6	51.5
Quick Crop,	June 19,	July 22,	⅛	221.2	54.6
Reeve's Rose,	June 19,	July 22,	⅛	187.9	36.4
Restaurant,	June 23,	July 24,	1/16	212.1	36.4
Rochester Rose,	June 19,	July 22,	⅛	212.1	48.5
Rose of Erin,	June 28,	July 22,	¼	221.2	9.1
Rose No. 9,	June 28,	July 22,	⅛	106.1	53.0
Secretary Wilson,	June 19,	July 22,	⅜*	266.7	60.6
Seneca Beauty,	June 19,	July 24,	⅛	209.1	24.3
Sir Walter Raleigh,	July 6,	July 29,	Trace.	148.5	21.2
Sir William,	June 19,	July 22,	⅜	181.8	21.2
Signal,	June 19,	July 22,	⅜	251.5	45.5
Somerset,	–	July 22,	⅛	169.7	18.2
State of Maine,	June 19,	July 24,	⅛	221.2	24.3
State of Wisconsin,	June 19,	July 22,	⅛	121.2	37.3
Table King,	June 23,	July 22,	⅜	230.3	25.8
Thorburn,	June 19,	July 24,	⅛	218.2	48.5
Tonhocks,	June 23,	July 22,	⅛	248.5	37.9

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Uncle Sam,	June 19,	July 22,	1/4	293.9	12.1
Vanguard,	June 19,	July 22,	1/8	277.6	34.9
Vick's Perfection,	June 19,	July 22,	1/8	284.9	39.4
Victory, P. and W.,	June 19,	July 22,	1/16	278.8	36.4
Vigorosa,	June 19,	July 24,	1/8	294.0	40.9
Washington,	June 23,	July 24,	1/16	240.9	28.8
White Elephant,	June 19,	July 29,	1/16	218.2	31.4
White Ohio,	June 23,	July 22,	1/4	230.3	24.3
White Peachblow,	June 23,	July 24,	1/16	125.9	42.4
Wisconsin Beauty,	June 19,	July 22,	1/4	251.5	25.8
Woodbury's White,	June 23,	July 22,	1/16	133.3	31.8
Early Andees,	June 23,	July 22,	1/4	–	–
Early Dawn,	June 28,	July 20,	1/4	–	–
Salzer's Earliest,	June 28,	July 15,	7/8	–	–
Triumph,	June 28,	July 15,	15/16	–	–

Variety Test Potatoes. Final Records.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Abundance,	–	Sept. 6,	230.3	21.2
Acme,	Aug. 12,	Aug. 14,	230.3	18.2
Algoma,	Aug. 12,	Aug. 24,	200.0	42.4
American Beauty,	Aug. 12,	Aug. 24,	266.7	12.1
Arizona,	Aug. 14,	Aug. 24,	236.4	30.3
Bartlett,	–	Sept. 5,	330.0	28.8
Beauty of Hebron,	Aug. 24,	Sept. 5,	342.5	48.5
Burpee's Superior,	–	Sept. 5,	266.7	30.3
Burr's No. 1,	Aug. 12,	Aug. 29,	351.5	36.4
Cambridge Russet,	Aug. 12,	Aug. 24,	233.4	22.7
Carmen No. 1,	Aug. 12,	Aug. 24,	287.9	36.4
Champion of the World,	Aug. 24,	Sept. 5,	269.7	42.4
Clay Rose,	Aug. 20,	Aug. 30,	281.8	33.3

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Commercial,	Aug. 14,	Aug. 30,	197.0	3.0
Country Gentleman,	Aug. 20,	Aug. 30,	315.2	51.5
Dakota Red,	Aug. 19,	Aug. 24,	206.1	18.2
Dreer's Standard,	Aug. 20,	Aug. 30,	312.1	18.2
Dutton's Seedling,	Aug. 20,	Aug. 30,	363.7	60.6
Early Kansas,	Aug. 20,	Aug. 30,	330.3	30.3
Beauty of Hebron,	Aug. 24,	Sept. 5,	393.9	39.4
Early Minnesota,	Aug. 20,	Aug. 30,	278.8	12.1
Early Roberts,	Aug. 12,	Aug. 23,	315.2	54.5
Early Rochester,	Aug. 28,	Aug. 30,	278.8	21.2
Early Rose,	Aug. 20,	Aug. 30,	351.5	66.7
Early Sunrise,	Aug. 20,	Aug. 23,	309.1	75.8
Extra Early Vermont,	Aug. 12,	Aug. 23,	327.3	60.6
Empire State,	Aug. 12,	Aug. 30,	206.1	24.3
Enormous,	Aug. 12,	Aug. 30,	397.0	15.2
Everett,	Aug. 23,	Aug. 30,	215.2	66.7
Fillbasket,	Aug 20,	–	416.2	45.5
Garfield,	Aug. 20,	Aug. 30,	236.4	30.3
German Queen,	–	Aug. 30,	275.8	36.4
Good Times,	–	–	229.1	27.3
Governor Rusk,	Aug. 14,	Aug. 23,	275.8	9.1
Green Mountain,	–	–	242.5	24.3
Howard,	Aug. 12,	Aug. 30,	403.1	51.5
Hurst,*	–	Aug. 8,	193.7	38.2
Mill's Longkeeper,†	–	Sept. 5,	177.6	46.7
Irish Cobbler,	Aug. 12,	–	297.0	45.5
Joseph,	Aug. 12,	Aug. 30,	260.6	30.0
King of the Earliest,	Aug. 12,	Aug. 14,	263.6	51.5
King of the Roses,	–	–	327.3	54.5
Lakeside Champion,	–	Aug. 30,	254.6	45.5
Late Puritan,	Aug. 23,	–	336.4	39.4
Lee's Favorite,	Aug. 14,	Aug. 24,	290.9	66.7
Leonard Rose,	Aug. 22,	Sept. 5,	345.6	57.6
Lincoln,	–	Sept. 5,	357.6	30.3
Maule's Thoroughbred,	Aug. 14,	Sept. 5,	321.2	48.5

* Forty-one hills. † Thirty-nine hills.

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Mayflower,	–	Sept. 5,	218.2	18.3
Mill's Banner,	–	Sept. 5,	272.8	10.6
Mill's Prize,	–	Sept. 5,	290.9	12.1
Money Maker,	–	Sept. 5,	287.9	21.2
Montana Wonder,	Aug. 12,	Aug. 23,	347.0	66.7
New Satisfaction,	Aug. 22,	Sept. 5,	297.0	30.3
Parker's Market,	Aug. 12,	Aug. 23,	234.9	30.3
Penn Manor,	Aug. 12,	Aug. 23,	339.4	60.6
Pingree,	Aug. 20,	Aug. 30,	303.0	24.3
Prince Bismark,	Aug. 12,	Aug. 23,	275.8	60.6
Prize Taker,	Aug. 14,	Sept. 5,	275.8	13.6
Early Potentate,	–	Aug. 23,	230.3	36.4
Pride of Michigan,	Aug. 12,	Aug. 23,	303.0	60.6
Prolific Rose,	Aug. 14,	Aug. 30,	351.5	97.0
Quick Crop,	Aug. 23,	Aug. 30,	309.1	66.7
Reeve's Rose,	Aug. 23,	Sept. 5,	345.5	54.6
Restaurant,	–	Sept. 5,	339.4	78.8
Rochester Rose,	Aug. 14,	Sept. 5,	303.0	72.7
Rose of Erin,	Aug. 14,	Aug. 20,	254.6	6.1
Rose No. 9,	Aug. 23,	Aug. 30,	236.4	34.9
Secretary Wilson,	Aug. 12,	Aug. 23,	290.9	54.6
Seneca Beauty,	–	Sept. 5,	345.5	60.6
Sir Walter Raleigh,	Aug. 23,	Sept. 5,	260.6	18.2
Sir William,	Aug. 14,	Sept. 5,	309.1	30.3
Signal,	–	Aug. 23,	284.9	54.6
Somerset,	–	Sept. 5,	278.8	18.2
State of Maine,	Aug. 23,	Sept. 5,	333.4	27.3
State of Wisconsin,	–	Sept. 5,	272.8	15.2
Table King,	Aug. 23,	Sept. 5,	300.0	27.3
Thorburn,	Aug. 12,	Aug. 24,	357.6	48.5
Tonhocks,	Aug. 23,	Sept. 5,	327.3	57.6
Uncle Sam,	Aug. 23,	Sept. 5,	330.3	36.4
Vanguard,	–	–	381.8	69.7
Vick's Perfection,	Aug. 12,	Aug. 30,	306.1	63.6
Victory, P. and W.,	Aug. 23,	Aug. 30,	321.2	48.5

Variety Test Potatoes, etc. — Concluded.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23. Large, Two Ounces or Above (Bushels).	Small (Bushels).
Vigorosa,	Aug. 23,	Aug. 30,	336.4	48.5
Washington,	Aug. 23,	Sept. 5,	404.6	22.7
White Elephant,	Aug. 23,	Sept. 5,	406.1	63.6
White Ohio,	Aug. 12,	Aug. 14,	272.8	48.5
White Peachblow,	Aug. 14,	Aug. 30,	321.2	60.6
Wisconsin Beauty,	Aug. 12,	Aug. 23,	257.6	48.5
Woodbury's White,	Aug. 23,	Sept. 5,	318.2	33.3
Early Andees,*	Aug. 10,	Aug. 14,	509.1	84.9
Early Dawn,*	Aug. 8,	Aug. 12,	509.1	72.7
Salzers' Earliest,*	–	Aug. 8,	434.4	36.4
Triumph,*	–	Aug. 5,	460.7	72.7

* 20 hills only grown.

Thirty-six varieties produce a yield of 55 pounds or over of large potatoes from forty hills when mature, this yield being at the rate of about 333 bushels per acre. These varieties are the following: Burr's No. 1, 351.5; Dutton's Seedling, 363.7; Beauty of Hebron, 393.9; Early Rose, 351.5; Enormous, 397; Fillbasket, 416.2; Howard, 403.1; Late Puritan, 336.4; Leonard Rose, 345.6; Lincoln, 357.6; Montana Wonder, 347; Penn Manor, 339.4; Prolific Rose, 351.5; Reeve's Rose, 345.5; Restaurant, 339.4; Seneca Beauty, 345.5; State of Maine, 333.4; Thorburn, 357.6; Vanguard, 381.8; Vigorosa, 339.4; Washington, 404.6; White Elephant, 406.1; Early Andees,* 509.1; Early Dawn,* 509.1; Salzer's Earliest,* 434.4; Triumph,* 460.7.

Eleven of these varieties gave at the earlier digging 40 pounds or over of large potatoes, which is at the rate of about 240 bushels per acre. These varieties are: Burr's No. 1, 262.1; Dutton's Seedling, 298.5; Beauty of Hebron, 287.9; Early Rose, 263.6; Enormous, 275.8; Howard, 275.8; Montana Wonder, 260.6; Penn Manor, 284.9; Prolific Rose, 257.6; Vanguard, 277.6; Vigorosa, 294.

* Quantity grown less than 40 sets.

There were besides 19 other varieties giving the same or higher yield at the earlier digging. These varieties are: Carmen No. 1, 295.5; Country Gentleman, 251.5; Dreer's Standard, 272.8; Early Kansas, 298.5; Early Roberts, 300; Early Vermont, 266.7; Irish Cobbler, 260.6; King of the Earliest, 265.2; Lakeside Champion, 245.5; Lee's Favorite, 278.8; Maule's Thoroughbred, 260.6; Prince Bismarck, 269.7; Prize Taker, 244; Secretary Wilson, 266.7; Signal, 251.5; Tonhocks, 248.5; Vick's Perfection, 284.9; Victory, P. and W., 278.8; Wisconsin Beauty, 251.5.

It will be noticed that the old Beauty of Hebron and Early Rose are found in both lists, thus ranking still among the most productive sorts, whether for early or late harvest.

There is surely no lack of good varieties of potatoes to choose from, and between many there can be but little difference in value. A single test does not warrant general conclusions. Good northern-grown seed is in my opinion of more importance than name. It is, however, evident that there are a few varieties on our list which seem unworthy of further trial. Among varieties which have made good yields three or more years may be mentioned: Beauty of Hebron, Dutton's Seedling, Early Rose, Enormous, Fillbasket, Prolific Rose, Restaurant, State of Maine, Thorburn, Vanguard and White Elephant.

Experiments in manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued. We have three large plots (between two and one-half and four acres each) under this treatment. Under this system each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds and muriate of potash 200 pounds per acre; and the third year, manure at the rate of 8 tons. The system is so planned that each year we have one plot under each manuring. The manure is always applied in the fall, the other materials early in the spring, — this year April 21 and 22.

Plot 1, which this year received barn-yard manure, applied Nov. 16, 1898, gave a yield at the rate of 2.095 tons

of hay and 0.5 ton of rowen per acre; plot 2, which received bone and potash, yielded 2.289 tons of hay and 0.479 ton of rowen; plot 3, which received ashes this year, yielded 1.58 tons of hay and 0.33 ton of rowen per acre. The field has now been eleven years in grass, and during the continuance of the present system of manuring (since 1893) has produced an average product (hay and rowen both included) at the rate of 6,630 pounds per acre. The plots when dressed with manure have averaged 7,027 pounds per acre; when receiving bone and potash, 6,568 pounds per acre; and when receiving wood ashes, 6,294 pounds per acre.

Poultry Experiments.

In experiments completed since our last annual report our attention has been confined exclusively to one point, viz., the comparison of a wide nutritive ration with a narrow ration for egg-production; or, in other words, of a ration in which corn meal and corn were prominent with one in which these feeds were replaced with more nitrogenous foods, such as wheat middlings, wheat and oats. So much greater is the cost of wheat than that of corn, that it seemed desirable to obtain as much evidence bearing upon their relative value for egg-production as possible at an early day. If the latter grain should, on further trial, prove so much superior to wheat as our experiments in 1898 indicated, the knowledge of the fact must prove of enormous value. Accordingly, we reared on the scattered colony plan well-bred pullets of the White Wyandotte, Black Minorca and Barred Plymouth Rock breeds, planning to have two houses (one on each feed) with twenty fowls each of each breed. In introducing purchased cockerels for breeding purposes late in the winter we unfortunately carried contagion, and an obscure form of what is commonly called roup broke out in such aggravated form among the Black Minorcas, that, fearing infection of the fowls in other houses, we killed all the Minorcas. The test with this breed was not, therefore, at all conclusive, and details will not be published. Up to the time the test was closed, however, the corn-fed Minorcas had laid about fifty per cent. more eggs than the others.

General Conditions.

The pullets were first evenly divided into lots of twenty each, being matched in sets of two as closely as possible. Each lot occupied a detached house, including laying and roosting room ten by twelve feet and scratching shed eight by twelve feet, with the run of large yards of equal size whenever weather permitted. The winter tests began October 15 and ended April 22. The hens were all marked with leg bands, as a precautionary measure for the purpose of identification in the case of accidental mixture of fowls.

All the meals and the cut clover were given in the form of a mash, fed early in the morning. At noon a little millet was scattered in the straw with which the scratching sheds were littered. At night the balance of the whole grain was fed (also by scattering in the straw) one hour before dark. The fowls were given what whole grain they would eat up clean. Water, shells and artificial grit were kept before the fowls at all times. About twice a week a small cabbage was given to each lot of fowls, this, like all other food, being weighed. The eggs from each lot were weighed weekly. The fowls were all weighed at intervals of about two months. Sitters were confined in a coop until broken up, being meanwhile fed like their mates.

The prices per hundred weight for foods, upon which financial calculations are based, are shown below :—

Wheat,	$1 60
Oats,	1 00
Millet,	1 00
Wheat bran,	85
Wheat middlings,	85
Gluten feed,	90
Animal meal,	1 75
Cut clover rowen,	1 50
Cabbage,	25
Corn meal,	90
Corn,	90

Narrow v. Wide Ration for Egg-production.

The experiments were in one sense continuous, as the same fowls were used throughout; but it is deemed best to report the results obtained during the cooler months and those of

the warmer months separately, one being denominated the *winter experiment*, the other the *summer experiment*. These experiments have for their object testing the correctness of the generally accepted view that the laying fowl should receive feeds very rich in nitrogenous constituents (*i.e.*, should have rations with a narrow nutritive ratio). During the tests of the past year corn has been much more largely used than in 1898. Then it replaced about one-half of the oats and wheat usually fed at night; this year the fowls on the wide ration received at night only corn. The fowls on both rations have received cut clover and animal meal in equal proportions.

The health of the fowls on both rations has been uniformly good through both the winter and summer experiments. As last year, however, it is found to require the exercise of more care to avoid overfeeding and loss of appetite among the corn-fed hens.

Winter Experiment.

This experiment, as has been earlier stated, began October 25. This was much too early to make possible the showing of a good record for total eggs, since the pullets did not begin to lay to any extent until January. The facts that they had been at large until the experiment began, after which they were closely confined, and that, as will be remembered, November and December were very cold and stormy, perhaps in large measure account for this. All details necessary to a full understanding of the experiments and the results, it is believed, will be found in the tables: —

Foods consumed, Narrow v. Wide Ration, October 25 to April 27.

KIND OF FOOD.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds).
Wheat,	333.00	–	333.00	–
Oats,	55.00	–	60.00	–
Millet,	57.00	56.00	57.50	58.00
Wheat bran,	42.11	42.00	41.30	42.00
Wheat middlings,	42.11	–	41.30	–
Gluten feed,	42.11	–	41.30	–
Animal meal,	42.11	42.00	41.30	42.00
Cut clover rowen,	40.07	40.00	37.80	40.00
Corn meal,	–	111.00	–	111.00
Corn,	–	408.50	–	436.00
Cabbage,	152.38	145.63	152.63	190.75

Average Weights of the Fowls (Pounds).

DATES.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
October 25,	4.3	4.3	4.9+	4.9
January 3,	4.6+	5.0+	5.1	5.6–
March 17,	4.6–	4.7+	5.4–	5.4+
April 27,	4.5–	4.3–	4.9–	4.9+

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

MONTHS.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
October,	-	6	11	7
November,	1	7	18	44
December,	9	33	38	44
January,	50	193	27	83
February,	159	228	57	194
March,	213	177	121	216
April,	179	199	112	168
	611	843	384	755

Narrow v. Wide Ration for Egg-production, Winter Test.

	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
Total dry matter in foods (pounds),	604.47	635.97	603.13	661.52
Number of hen days, not including males,	3,560	3,560	3,424	3,554
Number of hen days, including males,	3,622	3,622	3,548	3,678
Gross cost of food,	$9 26	$7 30	$9 25	$7 68
Gross cost of food per egg (cents),	1.50	.90–	2.41	1.02
Gross cost of food per hen day (cents),	.26–	.20+	.26	.21
Number of eggs per hen day,	.17+	.24–	.11+	.21+
Average weight per egg (ounces),	1.91–	1.82+	1.76	2.09
Total weight of eggs (pounds),	72.90	95.90–	48.24	98.62
Dry matter consumed per egg (pounds),	.99–	.75+	1.57	.88
Nutritive ratio,*	1:4.80–	1:6.30	1:4.80	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

Summer Experiment.

The method of feeding during the summer experiment remained the same as in the winter, save in two particulars: (1) in place of cut clover rowen in the mash every morning, lawn clippings in such quantity as the fowls would eat before wilting were fed three times per week to the hens in all the houses the same, and (2) the feeding of cabbages was discontinued. The yards, twelve hundred square feet in area for each house, were kept fresh by frequent use of the cultivator and spade. The health of all the fowls was good throughout this experiment. The tables give all details: —

Foods consumed, Narrow v. Wide Ration, May 1 to September 27.

KIND OF FOOD.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds.)
Wheat,	273	–	237	–
Oats,	59	–	52.5	–
Millet,	10	10	8	11
Wheat bran,	56	49	40	42
Wheat middlings,	56	–	40	–
Gluten feed,	56	–	40	–
Meat meal,	56	49	40	42
Corn meal,	–	129.5	–	111
Corn,	–	368	–	300

Average Weights of the Fowls (Pounds).

DATES.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
April 27,	4.50	4.30 —	4.90 —	4.90
June 2,	4.14 —	4.41 +	4.86	4.80
August 11,	4.28	4.68 +	4.88	4.88
September 27,	4.53	4.79	4.70	4.91

Number of Eggs per Month, Narrow v. Wide Ration, Summer Test.

MONTHS.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
May,	162	181	124	177
June,	140	198	156	217
July,	164	213	140	215
August,	158	213	112	128
September (27 days),	107	110	87	76
	731	915	619	813

Narrow v. Wide Ration for Egg-production, Summer Test.

	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
Total dry matter in foods (per cent.),	510.41	534.22	412.44	446.35
Number of hen days, not including males,	2,945	2,913	2,400	2,555
Number of hen days, including males,	3,245	3,213	2,573	2,735
Gross cost of food,	$7 50	$5 86	$6 14	$4 91
Gross cost of food per egg (cents),	1.03	.64	1.00	.60
Gross cost of food per hen day (cents),	.23	.18+	.24	.18
Number of eggs per hen day,	.25—	.31+	.26—	.32—
Average weight per egg (ounces),	1.88	1.90	1.82	1.77
Total weight of eggs (pounds),	85.89	108.70	70.40	89.94
Dry matter consumed per egg (pounds),	.70	.58	.67	.55
Nutritive ratio,*	1:4.20	1:6.30	1:4.40	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the total non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

It will be seen that the results of this year's experiments are in every particular similar to those of the experiments carried out in 1898.

The following are the most essential facts: —

1. The wide (rich in corn) ration appears to be much superior to the narrower ration. In all experiments, both summer and winter, the hens receiving corn have laid many more eggs than those receiving wheat.

2. The differences this year in favor of the wide ration, upon the basis of an equal number of hen days, are as follows: —

White Wyandotte, winter test,	41 per cent.
White Wyandotte, summer test,	24 per cent.
Barred Plymouth Rock, winter test,	91 per cent.
Barred Plymouth Rock, summer test,	23 per cent.
Last year the winter difference was	25 per cent.
Last year the summer difference was	$33\frac{1}{3}$ per cent.

3. The total cost of feeds was less for the wide ration, and of course the cost per egg was much less. In the production of one dozen eggs the saving amounted to from $4\frac{2}{3}$ to $16\frac{3}{4}$ cents.

4. The fowls on the wide ration gained more in weight than the others. Although laying many more eggs, they averaged at the end of the summer test nearly one-quarter of a pound each more than the others.

At the close of the summer experiment the fowls were most critically examined by a number of different parties, working independently, and all were unanimous in the conclusion that the corn-fed hens were farther advanced in the moult than the others. In my own opinion, the difference amounted to some two or three weeks in time. The corn-fed hens had shed all their old tail feathers, the others but few; the corn-fed hens had a large share of their new body feathers, the others had not shed the old. It was evident that the corn-fed hens were sure to begin laying again before the cold weather, while it seemed that the others were unlikely to do so. This judgment has been verified, for a small number of the corn-fed hens which were purchased by the writer have already laid one litter of eggs since October 1 and are beginning to lay a second, their plumage having been perfect for many weeks (December 20).

The great importance of an early moult in case hens are to be kept over is recognized by all. It makes all the difference between profit and a probable loss.

Our results with both breeds, both summer and winter, are thus greatly in favor of the ration richer in corn meal and corn. On its side we have: (1) lower cost of feed; (2) from 23 to 91 per cent. more eggs; (3) a far lower cost per egg, making possible a saving of from $4\frac{2}{3}$ to $16\frac{3}{4}$ cents per dozen in the food cost of their production; (4) a greater increase in weight; and (5) a much earlier moult.

It may here be remarked, using the words employed by the writer in a recent article, "that nature is generally a safe guide; 'Biddy,' kept healthy and vigorous, will take corn always in preference to wheat. Man conceived the idea that wheat is better for large egg-production. He has been endeavoring to convince the hen that she doesn't know what is good for her; and now it seems that, after all, her instinct and not his supposedly scientific reasoning has been right."

The writer is aware that under different conditions other results might follow. It is here particularly pointed out that our fowls are given plenty of space and fresh air, and that they are made to scratch vigorously for their whole grain.

REPORT OF THE BOTANISTS.

G. E. STONE, R. E. SMITH.

The work of this division has gone on steadily during the past year, having been almost entirely along the line of vegetable physiology and pathology. A large amount of correspondence has been carried on, along with the work of investigation. A considerable part of the work has been in connection with the growing of green-house crops, as in past years, lettuce, cucumbers and tomatoes receiving especial attention. The investigations outlined in our last report have been continued, and results obtained which in several cases are nearly ready for publication. The only entirely new subject of importance which has been taken up is that of aster diseases, which is referred to more fully later in this report. A bulletin on "The asparagus rust in Massachusetts" has been issued, containing the results of the investigation of this subject up to 1899. A further consideration of the same subject will be found in the present report.

Aster Diseases.

General complaint has been made of late years in all parts of the country of the trouble in growing asters, and at present more or less complete failure is almost universal. We have therefore commenced an investigation of this subject, with a view to ascertaining the exact nature of the trouble, and what may be done to prevent it. A large number of asters were grown during the past season, and, with the experience already gained, it is planned to grow many more next year, under various conditions which have suggested themselves as bearing on the trouble. Some valuable in-

formation has already been obtained, and it is hoped that another season's experience will afford considerable insight into the difficulties which now bid fair to prevent the raising of this popular and valuable flower.

Some Prevalent Diseases of the Year.

The following are some rather uncommon diseases which have been unusually prevalent during the past season: —

The Bacterial Cucumber Wilt.

In our last report we gave an account of a wilting of cucumber leaves, due to purely physiological causes. A disease of the same plant, and having a very similar effect, but caused by bacteria, is well known, and appeared in this vicinity in out-of-door cucumbers this year. In this case the bacteria which cause the trouble develop mostly in the ducts of the stem and leaf petioles, multiplying rapidly, and causing a stoppage of the flow of sap and hence a wilting of the leaves. The organisms can be readily seen, oozing out in little drops from the cut ends of affected parts. Pure cultures may be easily obtained from these drops.

No remedy can be given as yet for this disease, other than the removal and burning of affected plants.

A Geranium Disease.

In our annual report for 1897 we described a leaf-spot disease of the cultivated geranium (Pelargonium), which was thought to be caused by bacteria. It appeared at that time in a very wet season, and seemed more a result of the abnormal conditions than a true disease. The same trouble has been abundant during the past season, however, and appears to be a dangerous enemy to the growth of this plant. It causes small yellow and dead spots in the leaves, so that they fall off, and the plant becomes nearly denuded in the worst cases. Examination showed, as before, that the dead spots are full of bacteria, and no other organisms could be found, the former appearing to be the cause of the disease. Attempts were made to isolate the organisms, but

thus far without success; apparently it does not flourish under ordinary culture methods and conditions. Nevertheless, we have here, to all appearances, a genuine bacterial disease.

No remedy can be given for this trouble, beyond good cultivation and the production of vigorous plants. Cases have been seen where affected plants lost most of their leaves and produced a new crop, the latter more or less diseased, but still sufficient to present a fairly good appearance. The use of fungicides has no apparent value in such a case as this.

Muskmelon Failures.

Much complaint has been heard during the past season in this and other States of trouble with muskmelons. In our last report we described a disease of this plant caused by a fungus (*Alternaria*). The disease appeared again this year in the same and other places, and some weeks earlier than before, so that spraying experiments which we had planned were begun too late to be of value. Besides this disease, the common anthracnose (*Colletotrichum lagenarium* (Pass.) E. & H.) has been abundant, and very destructive both on muskmelons and watermelons. We saw one field of watermelons of unusually fine appearance completely ruined by this disease within a week. The stems and fruit were the parts most affected. There is every reason to believe that the Bordeaux mixture can be used with profit in these cases; but our experience this year has shown that if the treatment is not begun by July 1 or earlier, before any sign of disease has appeared, it will be entirely useless.

The Maple Leaf Blight. (*Phyllosticta acericola C. & E.*)

This disease, which affects several species of maple, has been known for some time, but has been much more abundant than usual during the past season. We have received it on sugar maple from several different parties. Large dead spots are produced in the leaves, which become curled and distorted, losing all beauty. Beyond this the actual injury to the tree is probably in most cases very slight.

The Chrysanthemum Rust.

This disease, which we first reported in 1897, appears to be on the decline in Massachusetts. It has been quite common the past season in various places, but in most cases has caused no apparent damage.

Some Experiments in growing Violets in Sterilized Soil.

Some experiments have been made this last year with violets, for the purpose of determining the relation between the production of flowers and the occurrence of leaf spots in sterilized and unsterilized soil respectively. For this purpose cuttings were made in the spring from mature plants and put into sterilized sand, after which they were transplanted into sterilized soil and removed out of doors, where they remained during the summer. In the fall they were transferred to the house and planted in a bed divided equally into two sections, each of which consisted of garden soil of good quality. One section of the bed was sterilized and the other section was not, and, in addition to this, the latter was inoculated with the parasitic nematode *Heterodera*. It should be stated, however, that the nematodes were not abundant enough in the inoculated soil to do any harm, as the bed was inoculated some time previous to setting out the violet plants, and, as no host plants were present, they died, or at least they did not gain any foothold upon the violets. The experiment is therefore largely one between sterilized and unsterilized soils.

Sterilizing the soil alone gives rise to beneficial results in the growth of a crop, a fact which we have already called attention to in Bulletin 55, issued from this station, and various experiments on different crops since has demonstrated the same thing.

Both of the beds were under tolerably equal conditions, at least so far as light and moisture were concerned; but a ventilator made some difference in the growth of a few plants in each section. The total number of plants employed in this experiment was fifty-four, and were of the variety known

as the Schœnbrun, which is not especially noted as a flower producer.

The following table shows the results of the experiment: —

Table showing the Monthly Production of Violets in Sterilized and Unsterilized Soil.

DATE.	Number of Blossoms picked.		Percentage of Gain.
	Unsterilized Soil.	Sterilized Soil.	
November,	19	38	100
December,	62	101	63
January,	55	125	127
February,	39	72	84
March,	144	250	73
April,	482	510	5
Total,	801	1,096	–
Average,	133	182	36

The results in the preceding table show a considerable increase in the production of blossoms as a result of sterilizing the soil. The percentage of gain of the sterilized plat over that in the unsterilized was 36. It will be observed also that the gain in flower production in general was most marked during the first half of the experiment, and the flower production falls off in the sterilized earths in the succeeding months, until in April, when the experiment was discontinued, the gain was only 5 per cent. over that of the unsterilized. The maximum occurred during the third month (January), although this might not occur in every instance, as a large number of experiments would probably modify these results.

Observations were made in regard to the number of leaf spots in the two plats, with the result that the sterilized plats gave the smallest number, hence showing that vigorous plants are less susceptible to fungi.

The methods employed in sterilizing the soil were the same as those described on page 54 in Bulletin 55, from this station.

In regard to the practice of sterilizing soil for the purpose

of growing plants, we will state that, while there is no doubt as to the beneficial results obtained by sterilizing the same soil for two or three crops, it does not necessarily follow that soil will repeatedly stand this treatment and give good crops.

Within the last year sterilized soil has been recommended for home culture purposes, and those who use it claim to have obtained superior results.

The Relationship existing between the Asparagus Rust and the Physical Properties of the Soil.

The past season has been most favorable to the outbreak of the asparagus rust, which has manifested itself in a severe manner in the same localities where it has occurred during the last few years. The unusually dry spring enabled us to predict to asparagus growers the probable occurrence of the rust for last summer; and, as the rust has usually shown itself the season following an outbreak, regardless of the weather conditions, we may expect to encounter the same next summer (1900), at least in those beds which were badly affected and weakened from the attacks of 1899. We have endeavored to point out in Bulletin 61, issued from this station, the relationship existing between dry seasons and the occurrence of the summer or injurious stage of the rust, and also the susceptibility of plants growing in localities possessing soil with little water-retaining properties. Our observations and experiments during the past season have not led us to reverse any of the conclusions set forth in this bulletin, but, on the other hand, we are more strongly convinced of their validity. These conclusions are based upon an extensive study of the localities affected, and the object of the present article is to call attention to additional data relating to the distribution of the rust in Massachusetts, and the relationship existing between the outbreak of the rust and the rainfall, together with the physical properties of the soil. For the past three seasons we have paid attention to the distribution of the rust in Massachusetts, although the regions infected during the past summer (1899) scarcely differ from those infected during previous years.

Attention was first called to the asparagus rust in the fall of 1896. During 1897, although an extremely wet season, the damage by the rust was severe. Its occurrence during this season, however, was merely an after-effect, the primary cause being due to the injury caused by the preceding dry seasons. In 1898 the summer stage of the rust was scarcely perceptible; while in 1899 (the past season) the rust was severe, on account of the want of soil moisture.* The fall stage of the rust (black or teleuto spore stage), which is, according to our estimation, a harmless stage, and not worth paying much attention to, has been universally distributed over the State since 1896. There has, however, been some tendency for it to become less common during the last two years. This stage usually occurs during September and October, about the time when the asparagus plants first commence to lose their green color and turn yellow, the appearance of this stage being associated with the disintegration and death of the plant. The summer stage of the rust (red or uredo stage), which is in every instance an injurious stage, occurs during July and August. It occurs about July 11, or later, on beds from which a crop has been marketed, and spreads very rapidly with the wind, as is evident by those sides of the asparagus plant being first infected which correspond with the prevailing direction of the wind. We have no data as to any earlier appearance of the rust on young plants which have not been cut for the market, and it would not be at all improbable that they become infected earlier than July 11. The summer stage of the rust, however, is limited in its distribution in Massachusetts, and is found only on those soils which are sandy, and possess little water-retaining properties. The sand increases as we approach the sea-coast, and the soils which support asparagus plants affected with the red rust are found with some local exceptions in the eastern part of the State.

The summer stage of the rust has never been observed by us, nor has it been reported (with one exception, which we will refer to later, and which is local) any further west than the towns of Berlin and Northborough, which are east of the

* The amount of rainfall from April 1 to September 1 in 1899, at Amherst, was 14.09 inches; that for the same period in 1898 was 23.97 inches.

meridian 71° 40′. (See map.) These towns would appear to be on the border zone of the uredo spore outbreak, and the occurrence of the rust here is by no means so universal as it is in the sandier region of Cape Cod. Some of the growers situated upon the border zones of infection may have the summer stage badly one season and the next season be free from it. The soil of this region offers sufficient differences in texture from the more sandy coast soils, so that sound, vigorous plants might be expected to be proof against the rust in any season, and the outbreak here might be largely prevented by careful cultivation and feeding of the plants.

An examination of the map (fig. 1) will show those portions of Massachusetts in which the summer stage of asparagus rust has appeared up to the present time. The only region infested with this stage of the rust in Massachusetts west of the meridian 71° 40′ is in the Connecticut valley, in the vicinity of Montague, where the soil is remarkably sandy and dry, while other portions of the Connecticut valley which possess more or less heavier soil have been entirely free from this stage. The affected area shown on the map is characterized by a loose sandy soil, which possesses less water-retaining properties in most instances than the soils of their immediate vicinity. In order, however, to show more definitely the differences existing between the texture of the soils of the eastern part of the State and those of the central and western parts, we have made a number of mechanical analyses of the soils of various regions, which include many from the infected asparagus fields. Any one who has paid special attention to our Massachusetts soils and their influence upon the development of plants would not require a mechanical analysis in order to become convinced of the differences existing between them, as a glance at the soils in the field would be sufficient. Nevertheless, a mechanical analysis will show us the exact differences existing between the textures of the soil of the various regions, and we will moreover be able to demonstrate the amount of difference exhibited in their water-retaining capacity. The following table gives the data of the mechanical analysis*

* The methods of analysis employed are those of Prof. Milton Whitney.

of ten typical surface soils from various parts of the State between the Cape and the New York State line : —

TABLE I. — *Showing the Mechanical Analyses* of Ten Massachusetts Soils, extending from Cape Cod to Western Massachusetts. — Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in 20 Grams of Soil.*

[Diameter of the grains in millimetres (1 millimetre equals about 1/25 inch) : gravel, 2-1; coarse sand, 1-.5; medium sand, .5-.25; fine sand, .25-.1; very fine sand, .1-.05; silt, .05-.01; fine silt, .01-.005; clay, .005-.0001.]

SAMPLE.	Water.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Orleans,	1.82	2.20	20.97	31.03	19.70	12.26	6.26	2.77	1.46	1.37
Bridgewater,	1.86	2.10	17.92	28.80	18.85	5.80	19.15	2.85	1.34	.66
Eastham,	1.66	2.00	9.38	27.91	25.09	21.43	8.70	1.40	.77	1.43
Concord,	1.66	4.19	4.24	10.20	12.81	27.93	34.11	1.84	1.73	1.08
Attleborough,	8.13	7.64	9.26	11.15	7.87	11.53	29.50	10.95	2.51	1.42
Worcester,	3.00	9.40	1.65	2.80	4.25	19.85	42.95	4.50	2.95	2.75
Spencer,	3.40	9.80	2.70	4.55	7.30	22.35	29.60	6.65	2.45	3.25
Montague,	.90	1.86	.27	4.39	19.85	43.88	25.75	2.63	.36	.27
Amherst,	2.98	7.31	.95	1.25	1.72	7.28	66.19	6.96	1.33	4.13
Pittsfield,	9.50	11.25	5.50	5.95	5.02	13.87	36.15	6.45	.87	5.40

* Analyzed by A. A. Harmon and Asa S. Kinney.

The first six soils represent typical samples taken from affected fields in locations where the summer stage of the rust has always been present since its occurrence in Massachusetts, and in most instances where it has been severe. The other samples are from towns which have not shown the summer stage of the rust, but in which the fall stage has occurred. All of the samples are so-called surface soils, and represent single analyses. Except in the Amherst soils they represent an average of four analyses, while in the Pittsfield there is an average of two. A careful examination of the table will show considerable difference in the texture of the soils of the various regions. It will be observed that the coarse elements are much more common in the coast soils than in the inland soils, and conversely that the fine elements are greatly increased in the inland soils.

In order to obtain a better idea of the relative amounts of the various constituents found in the different soils, we can arrange them as in Table II., in which the average constituents contained in the four coast soils are shown alongside of four inland soils which are characteristic of the central and western regions of Massachusetts. The four coast soils represent badly infested regions, while the four inland soils represent those in which only the fall stage has occurred.

TABLE II. — *Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in Orleans, Eastham, Concord and Bridgewater (Coast Soils), and Worcester, Spencer, Amherst and Pittsfield (Inland Soils).*

SAMPLE	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Four coast soils, ...	2.62	13.12	24.48	19.11	16.85	16.80	2.21	1.32	1.13
Four inland soils, . . .	9.44	2.70	2.63	4.57	15.83	18.72	6.14	1.90	3.88

The largest amount of gravel as shown by the table is in the Orleans soil from Cape Cod, which is 20.97 per cent.; the average for the whole is 13.12 per cent., against 2.70 per cent. for the inland soils. What holds true in regard to the gravel is also true when we consider the coarse sand, where the proportion is 24.48 per cent. in the coast soil, to 2.63 per cent. in the inland soils; while in the medium sand it is 19.11 per cent. to 4.57 per cent. Only slight differences are shown in the proportion of fine and very fine sand between the two regions, although the coast soils are ahead in the former and the inland in the latter; whereas in both of the silts and clay the largest amounts are found in the inland soils. If we turn to the organic matter, we find that it is also more abundant in the inland soil than it is in the coast soil. This difference is partly accounted for by the fact that some of the samples of inland soil represent highly manured soils, adapted to intensive cultivation. Even making allowances for this fact, the organic matter would seem higher in the inland soils than in the coast soils, inasmuch as various samples of soil

taken from inland localities which were not manured gave an average of about 6 per cent., or about three times as much as that shown by the coast soils. This is not true, however, of the coast soils such as are used for general truck farming, — as in the case of Arlington, for example, — in which instance we would find the percentage of organic matter quite large. The amount of water in the soils differs also, which is caused by the analyses of some of the samples being taken at different times, and from not being subject to the same air-drying conditions. It will also be noticed that the Attleborough soil contains an unusually large amount of silt, — a feature which seems to be peculiar to that soil alone. As a rule, the inland soils contain a very large amount of very fine sand, and this appears to be especially characteristic of the Connecticut valley soils. Some analyses which we have made show that this soil sometimes possesses as much as 75 per cent. of this constituent. It is the excessive amounts of this constituent of the soil which renders the Amherst soil compact, and which gives to it an increased water-retaining capacity. The clay, however, shows a gradual increase as we pass inward, and in a less uniform manner is this exhibited by the silt, which can be seen by examining Table III.

TABLE III. — *Showing the Percentage of Gravel-Sand, Silt and Clay in the Soils shown in Table I.*

SAMPLE.	Gravel-Sand.	Silt.	Clay.
Orleans,	90.22	4.23	1.37
Bridgewater,	90.52	4.16	1.13
Eastham,	92.51	2.17	1.43
Concord,	89.35	3.57	1.08
Attleborough,	69.39	13.46	1.42
Worcester,	71.50	7.45	2.75
Spencer,	66.50	9.10	3.25
Montague,	94.15	2.99	.27
Amherst,	77.39	8.29	4.13
Pittsfield,	66.49	7.32	5.40

There are inland soils which contain considerable amounts of sand, such as the Connecticut valley soils, for example,

thus offering exception in this respect to the surrounding localities. The Montague soil is one of these, and it will be noticed by examining Table III. that the percentage of sand is very high in this. It is not, however, the coarser varieties but the finer which predominate, thus differing widely from the sandy soil of Cape Cod. Notwithstanding this variation, a large number of analyses show that the clay appears to follow, as a rule, what might be termed a normal amount for each particular region. It is therefore interesting to note in this connection that the increase of clay as we pass inward is fully as characteristic and uniform in the Massachusetts soils as is the decrease of the sand. The differences existing between the texture of the coast and inland soils are sufficient to exert considerable influence upon the growth of plants. This difference is equally perceptible, whether we see the soils in the field or in a table showing their analyses.

Having paid some attention to the physical properties of a few of our State soils, and their effect upon plant development, we are able to ascertain approximately from a mechanical analysis the characteristic properties of the constituents, and what effect they exert upon the development of certain crops. As a rule, we can divide the various constituents directly in the middle; that is, we can consider the four coarser elements and the four finer constituents by themselves. Such an arrangement of the soils is shown in Table IV.

TABLE IV. — *Showing Soils as in Table I., arranged according to the Percentages of Gravel and Coarse, Medium and Fine Sand, the Very Fine Sand, Silt and Clay being omitted.*

Orleans, ...	83.96	Attleborough, . .	39.81
Eastham, ...	83.81	Spencer, ...	36.90
Bridgewater, . . .	71.37	Pittsfield, . . .	30.34
Montague, ...	68.39	Worcester, . . .	28.55
Concord, ...	55.18	Amherst, . . .	11.20

If, for example, a soil is rather low in the constituents represented by the gravel and coarse, medium and fine sand,

and correspondingly high in the remaining constituents, then we possess a soil which is characteristic of the inland types, and will pack down very closely when wet. If, however, the reverse of this is true, we find a loose, pliable soil, such as is found on the coast, which is easily worked and especially adapted for truck farming. The latter soil will not retain much water, it quickly dries out; while the former or inland soil will retain considerable water for a long time, inasmuch as the resistance and relative amount of water maintained by different soils depends upon the volume of space in the soil for the water to enter, which in turn depends upon the number of grains of sand, silt and clay. In sandy soils the space is not divided up as much as in a clay soil; the grains of sand being larger, the spaces between the grains are also larger, there is less friction, and the water moves downward more quickly. The order of arrangement of the soils in Table IV. (which is that relative to the coarse material they contain) follows very closely the water-retaining capacity of the soils, as we shall see when we come to Table V.

These are in part the principal differences existing between the coast and inland soil, with now and then an exception; and the outbreak of the summer or injurious stage of the asparagus rust is always characteristic of those soils which are sandy and porous, and consequently possess little water-retaining capacity, whether they are located near the coast or inland. It should, however, be borne in mind that it is not the percentage of coarse and fine material alone which is responsible for the character of a soil, but the shape and arrangement of its particles exert an influence upon it. Then, again, the organic matter, the depth of the soil and the nature of the sub-soil, as is well known, are important when the question of moisture and dryness is concerned. We have already pointed out that the four soils from the coast contain less organic matter than those from inland soils, and this fact holds good for the Montague sample also. If these soils were richer in organic matter, their water-retaining properties would be increased, and they would become less susceptible to the rust.

In order to test the water-retaining properties of some of these samples of soil, we subjected them to the following

treatment. Three hundred grams of the air-dried soils were taken and put into a cylinder three inches wide and six inches high, with a perforated bottom, over which there was placed a layer of filter paper. The cans containing the soil were then weighed, after which the samples were liberally treated with water until they contained all that was possible for them to hold. The cylinders were then set aside, and after the water had stopped dripping they were again weighed, and the additional weight which was due to the amount of water applied was noted. This represented the amount of water which the soils could retain. Other air-dried samples of the same soil were heated in an oven to perfect dryness, and by this means the amount of hygroscopic water was obtained for each. This, being added to the amount of water retained, gave the total water capacity of the soil; and, dividing this sum by the weight of water-free soil, which was obtained by subtracting the hygroscopic water from the original three hundred grams, we obtain the percentage of water which each soil is capable of retaining; or, in other words,

$$\frac{\text{Water retained} + \text{Hygroscopic water}}{\text{Water-free soil}} = \%\text{ of water-retaining capacity.}$$

The following table gives the results of these experiments in the order of water-retaining capacity: —

TABLE V. — *Showing the Retentivity of Soil Moistures in Order of Retaining Capacity.*

SAMPLE.	Water retained (Grams).	Hygroscopic Water (Grams).	Weight of Water-free Soil (Grams).	Percentage of Water retained.
Orleans,	103.0	2.10	297.90	35.28
Bridgewater,	99.5	.66	299.34	37.13
Eastham,	115.9	.78	299.22	38.99
Montague,	144.8	.90	299.10	48.71
Concord,	145.3	2.76	297.24	49.81
Attleborough,	168.9	4.20	295.80	58.52
Amherst,	200.6	2.82	297.18	68.45

As might be expected, the coast soils show the smallest percentage of water-retaining capacity, and this percentage

increases as we pass inland to the heavier soils, as would naturally follow. The smallest percentage is shown by the soils from Cape Cod, where there is a considerable amount of coarse material and small amounts of fine material; while the largest percentage is given by the Amherst soil, which contains a larger amount of fine material and a less amount of coarse material than the coast soils. The Amherst soils show 68.45 per cent. water-retaining capacity, against 35.28 per cent. for the Orleans; or, in other words, the Amherst soil possesses nearly twice the water-retaining capacity of the Orleans soil. Only two determinations were made of the water-retaining properties of the soil west of Worcester, one being at Montague, where the summer stage of the rust is present, and the other at Amherst, where it has never occurred. These two determinations are, however, sufficient for our purpose; inasmuch as the preceding table shows that the water-retaining properties of the soil decrease in loose, sandy soil, and increase in fine, compact soil; and, as the mechanical constituents of such soils as the Worcester, Spencer and Pittsfield are larger in fine material and more closely resemble the Amherst soil than those of the coast, we would therefore find similar water-retaining properties.

The cans containing the soils were left in a room of even temperature, and after five days had elapsed they were weighed again, with the following result: —

TABLE VI. — *Percentage of Water lost by the Following Soils after Five Days.*

Bridgewater, ...	75.07	Attleborough, . .	46.95
Orleans, ...	73.78	Montague, . . .	40.33
Eastham, ...	66.17	Amherst, . . .	23.33
Concord, ...	51.75		

These results follow in a general way those shown in Table V. The Bridgewater, however, lost slightly more than the Orleans. As most of these soils were gathered within a few days of each other, it may be of some interest to note the amount of water found in each at the time the samples reached the laboratory. Amherst gave 33.60 per cent. of

water; Montague, 11.26 per cent.; Orleans, 12.50 per cent.; Attleborough, 15.40 per cent.; Concord, 8.65 per cent.; Eastham, 5.69 per cent.; Bridgewater, 3.74 per cent. These figures do not possess any great value, but in a general way they correspond with those in the preceding table. The variation in the amount of rainfall in different parts of the State of course comes into account here. We will state, however, that the Amherst soil referred to was taken from an asparagus bed which has never had the rust in any stage, — a fact which is not only due to its characteristic texture and the nature of the subsoil, but to the fact that the plants have been thoroughly cultivated and properly fed, and consequently are in a very vigorous condition. According to Professor Brooks, this bed has at times received a heavy dressing of cow manure in the fall, which has been forked in in the spring, and then fertilizer has been put on at the following rate per acre: muriate of potash, 600 pounds; nitrate of soda, 200 pounds; and acid phosphate, 900 pounds.

Asparagus growers have stated that there is a difference as to infection in different parts of a field. Many have stated that the drier places were the most badly infested, while others could notice no difference, or in some instances those parts which they considered the least dry showed the rust the worst. This latter condition does not in any way affect our conclusions that the rust (summer stage) is peculiar alone to those regions that possess sandy soil which has little water-retaining capacity, inasmuch as our conclusions are general, and refer to the State as a whole. That exceptions do occur even in a single bed is not at all strange, so long as plants are endowed with a tendency to vary. There are other factors which have a bearing on the susceptibility of plants to rust other than those of soil and water conditions, among which is the general health condition or vigor of the plant. We have repeatedly observed in the same bed numerous plants that were badly infected, while directly beside them were some which were perfectly healthy. We do not maintain, however, that, in a bed where the plants possess the same amount of vigor and where they are under exactly similar conditions except in regard to moisture, those in the dry place will succumb to the rust quickest and become more

severely affected than those located in dry places. The principal feature which we wish to emphasize in connection with these experiments is that the summer stage of the asparagus rust is due to a weakened condition of those plants growing on dry soil during seasons of extreme drought. In other words, the plants suffer for water; and, since this is the case, the rational method of prevention must take the amount of soil moisture into consideration. It will not be out of place here to reflect upon the present status of the rust problem, and consider the methods which should be employed in our endeavors to control it.

The practice of spraying, it would seem, is not likely to give promise of any remarkable results, because the asparagus plants offer difficulties in this respect, and all of the rusts are hard to control. Stewart found, in his experiments on spraying for the carnation rust, which attacks a host largely confined to greenhouses and therefore much better under control, that the best results obtained by spraying were not very promising. Then, again, it is possible that the asparagus rust mycelium may be confined to the plant throughout the year, in which case the value of spraying would be practically useless. We have observed a fungous mycelium in the roots and stems of the asparagus plants below the ground long before any occurrence of the rust showed upon the aerial stems; but whether the mycelium was identical with that of the rust, or of other parasitic fungi frequently found upon the asparagus, we were not able to ascertain. We must therefore turn our attention to other methods of control, — to methods which will enable us to keep the plants under more normal conditions during seasons of drought. These methods will consist, first, of securing the most vigorous plants, — a feature which is dependent upon cultivation and the proper kinds and amounts of plant food with which the plants are supplied. There is considerable difference in the plants of various growers in this respect; the most vigorous and largest plants which we have observed were situated in a dry region, subject to uredo infection, but they have never suffered from the rust till this season. The amount of rainfall between April 1 and September 1 of this year has been the lowest for many years, and many beds have shown the summer stage for the first time this year. It is interesting

to note, however, that cultivation and skilful plant feeding alone have enabled some beds to suppress the outbreak of the summer stage.

Then, again, the question of soil moisture during dry seasons must be considered. There are different ways of securing this, such as by irrigation, by increasing the organic matter in the soil, or by mulching. In selecting a site for new beds, they should be started on soil possessing some degree of water-retaining capacity, even if such soil is not adapted quite so well for asparagus during ordinary seasons. We are convinced, however, that soils such as the Montague and Attleborough, which appear to be good asparagus soils, possess enough fine material and sufficient water-retaining capacity to prevent the summer outbreak, provided robust plants are secured. In fact, we are informed that the summer stage of the rust has not appeared on the beds at Attleborough from which this sample was taken previous to this year. It is these extremely light, sandy soils that have been selected for the largest asparagus beds, because they appear to be best adapted for its growth. Numerous inquiries from towns adjoining many of these badly infected regions have failed to show any evidence of injuries from the rust, as the texture of the soil is slightly different.

If the asparagus rust continues to cause as much injury in the future as it has in the past, it may become necessary to resort to those soils of a finer texture for the cultivation of this crop. The matter of irrigation would be expensive and not readily resorted to on many beds, while others that we know of could be very easily irrigated by damming a small stream and properly diverting the course of the water. Since the asparagus rust is brought about by drought, and is therefore not likely to cause much injury except during such seasons, the occurrence of the disease can be anticipated. In this respect it differs from other common plant diseases, inasmuch as we have to spray for them every season, whether we know they are going to make their appearance or not. An annual treatment would therefore not be required. It is hoped that some preventive measures, based upon the retentivity or the supplying of soil moisture, will be employed by those growers who are favorably situated and who have suffered from the rust.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of this division the past year has been principally devoted to the observation of the various weather phenomena, together with the reduction of the records and their arrangement in form for preservation.

The usual monthly bulletins, giving the more important daily records and a review of the character of the weather, have been issued, and the annual summary will be published as soon as the records for the year are complete.

Throughout the year the New England section of the United States Weather Bureau has furnished us daily, except Sunday, with the local forecasts of the weather, and the signals have been displayed from the top of the tower. Arrangements have been made to furnish them the weekly snow reports, as heretofore.

The observations relating to soil temperature and moisture by the electrical method, begun two years ago, have been continued this year. Owing to the unsatisfactory results of the previous years, the temperature cells and moisture electrodes were tested and standardized before using them in the field. The temperature cells were placed in water and the resistances observed. After the resistances became constant for each cell, the temperature of the water was taken by a standard thermometer. The resistance of each cell was thus determined, for temperatures varying by about 10° F., for a range exceeding that which it would be subjected to in the field. The cells were afterward placed in soil in a box, and the resistances observed and the temperature computed by the tables in Bulletin No. 7 of the United States Department of Agriculture, Division of Soils, and checked by using a standard thermometer. The standardization of the moisture

electrodes was effected by placing them in soil in boxes so arranged as to provide for a proper diffusion throughout the soil of water as added, taking the resistances and computing the percentage of moisture from the weight. When afterward used in the field these electrodes gave more satisfactory results than had before been attained. The results for the corn-growing season of the current year have been worked out. The observations will be continued next year, for purposes of comparison.

The means of the various weather elements for each month and year, for the ten years from 1889 to 1898 inclusive, have been tabulated, and normal conditions for the period deduced. These results are of especial interest for the purpose of noting departures from normal conditions. The tabulations, together with other data of interest, will be found on the following pages.

Meteorological Observatory of the Hatch Experiment Station, Massachusetts Agricultural College, Amherst.

General Summary, 1889–98.

Latitude of observatory, 42° 23′ 48.5″ N.; longitude, 72° 31′ 10″ W. Elevation of ground at base of observatory above mean low water, Boston harbor, 223 feet, as determined by levels connecting with those of the Boston & Maine Railroad. The standard barometer is 50.5 feet above the ground and 273.5 feet above sea level. The Draper self-recording barometer is 51.5 feet above ground. The cup anemometer, pressure anemometer, anemoscope and sun thermometer are located on top of the tower, 72 feet above the ground. All temperatures are taken in the thermometer shelter on the campus, about 4 feet above ground and 220 feet above sea level. The standard rain gauge is on the campus, about 2 feet above the ground and 218 feet above sea level.

Mean Barometer.

[Readings are reduced to freezing and sea-level.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean Annual.
1889, ...	30.113	30.238	29.843	29.795	29.916	29.960	29.909	30.008	29.999	30.050	30.040	30.139	30.001
1890, ...	30.191	30.097	29.993	30.098	29.959	29.975	30.019	30.001	30.124	29.880	30.007	30.013	30.030
1891, ...	29.958	30.041	30.099	29.923	29.983	29.919	29.986	29.965	30.114	30.028	30.117	30.081	30.018
1892, ...	29.965	30.106	29.895	29.972	29.943	29.923	29.988	30.017	30.103	29.896	29.988	30.010	29.983
1893, ...	29.951	30.111	30.065	30.086	29.895	30.056	29.968	30.001	30.065	30.126	30.124	30.120	30.047
1894, ...	30.175	30.160	30.088	30.054	30.000	29.997	30.012	30.033	30.143	30.016	30.081	30.148	30.085
1895, ...	30.047	29.918	29.998	30.119	30.097	30.172	30.031	30.016	30.097	30.082	30.187	30.151	30.076
1896, ...	30.158	29.860	29.990	30.143	29.984	29.949	29.974	29.989	30.004	30.011	30.145	30.135	30.028
1897, ...	30.041	30.056	30.036	30.042	29.924	29.901	29.943	29.943	30.091	30.122	30.034	30.036	30.014
1898, ...	29.976	30.052	30.203	29.927	29.937	29.947	30.017	29.959	30.012	30.089	30.010	29.963	30.008
Mean, . . .	30.057	30.064	30.021	30.016	29.964	29.980	29.985	29.993	30.075	30.030	30.073	30.080	30.029

Range of Barometer (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889,	1.62	1.51	1.58	1.16	.75	.97	.68	.66	.98	.96	1.31	1.75	1.81
1890,	1.50	1.35	1.08	1.08	.81	.58	.63	1.10	.69	1.09	.98	1.20	1.76
1891,	1.93	1.36	1.21	1.42	.79	.53	.74	.61	.73	1.11	1.56	1.22	2.05
1892,	1.38	1.65	1.16	1.02	.96	.84	.97	.55	.96	.98	1.00	1.01	1.65
1893,	1.53	1.83	1.27	1.25	1.16	.67	.68	.93	.81	1.37	1.16	1.53	1.92
1894,	1.89	1.65	1.04	.86	.93	.75	.57	.44	1.11	1.19	1.22	1.23	2.01
1895,	1.46	1.88	1.24	1.40	.84	.66	.51	.53	.68	1.09	1.47	1.78	2.27
1896,	.97	1.77	1.52	.96	.75	.83	.79	.59	.85	1.10	1.23	1.57	2.22
1897,	1.57	1.15	1.74	1.10	.76	.55	.72	.61	.73	1.12	1.48	1.42	1.76
1898,	1.43	1.63	1.17	.86	.76	.95	.81	.60	.82	1.19	1.25	1.39	1.75
Mean,	1.53	1.58	1.30	1.11	.85	.73	.71	.66	.84	1.12	1.27	1.41	1.92

Maximum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,	30.82	30.97	30.66	30.54	30.40	30.54	30.35	30.45	30.40	30.52	30.67	30.96	30.97
1890,	30.94	30.72	30.56	30.57	30.32	30.28	30.27	30.28	30.42	30.41	30.35	30.61	30.94
1891,	30.62	30.69	30.57	30.56	30.44	30.22	30.37	30.27	30.45	30.67	30.74	30.55	30.74
1892,	30.67	30.72	30.45	30.53	30.43	30.39	30.50	30.24	30.42	30.43	30.44	30.53	30.72
1893,	30.61	30.83	30.63	30.65	30.32	30.36	30.25	30.30	30.45	30.65	30.70	30.92	30.92
1894,	30.77	30.89	30.57	30.52	30.50	30.33	30.31	30.24	30.63	30.42	30.73	30.53	30.89
1895,	30.61	30.44	30.52	30.70	30.55	30.51	30.33	30.29	30.41	30.67	30.73	30.83	30.83
1896,	30.56	30.49	30.62	30.60	30.48	30.42	30.49	30.39	30.40	30.62	30.86	30.94	30.94
1897,	30.77	30.70	30.88	30.61	30.36	30.28	30.33	30.18	30.40	30.67	30.60	30.60	30.88
1898,	30.61	30.64	30.76	30.34	30.33	30.35	30.44	30.26	30.41	30.46	30.53	30.52	30.76
Mean maximum,	30.70	30.71	30.62	30.56	30.41	30.37	30.36	30.29	30.44	30.55	30.63	30.70	30.86

Minimum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889,	29.20	29.46	29.08	29.38	29.65	29.57	29.67	29.79	29.42	29.56	29.36	29.21	29.20
1890,	29.44	29.37	29.48	29.49	29.51	29.70	29.64	29.18	29.73	29.32	29.37	29.41	29.18
1891,	28.69	29.33	29.36	29.14	29.65	29.69	29.63	29.66	29.72	29.56	29.18	29.33	28.69
1892,	29.29	29.07	29.29	29.51	29.47	29.55	29.53	29.69	29.46	29.45	29.44	29.52	29.07
1893,	29.08	29.00	29.36	29.40	29.16	29.69	29.57	29.37	29.64	29.28	29.54	29.39	29.00
1894,	28.88	29.24	29.53	29.66	29.57	29.58	29.74	29.80	29.52	29.23	29.51	29.30	28.88
1895,	29.17	28.56	29.28	29.30	29.71	29.85	29.82	29.76	29.73	29.58	29.26	29.05	28.56
1896,	29.59	28.72	29.10	29.64	29.73	29.59	29.70	29.80	29.55	29.52	29.63	29.37	28.72
1897,	29.20	29.55	29.14	29.51	29.60	29.63	29.61	29.57	29.67	29.55	29.12	29.18	29.12
1898,	29.18	29.01	29.59	29.48	29.57	29.40	29.63	29.66	29.59	29.27	29.28	29.13	29.01
Mean minimum,	29.17	29.13	29.32	29.45	29.56	29.62	29.65	29.63	29.60	29.43	29.37	29.19	28.94

Mean Temperature (in Degrees F.).

[Completed from daily maximum and minimum readings.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Mean.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890,	29.2	32.0	31.0	45.8	56.3	65.3	68.4	67.2	60.4	48.2	37.2	21.8	46.9
1891,	26.4	27.6	32.7	47.5	55.6	65.2	66.3	69.0	64.9	48.7	38.1	36.9	48.2
1892,	23.6	26.1	31.4	45.2	56.0	69.3	69.3	68.9	59.3	48.6	37.8	26.3	46.8
1893,	16.1	22.9	30.4	43.0	55.8	66.9	68.1	69.2	55.8	52.6	38.2	25.5	45.4
1894,	26.4	21.6	39.6	46.7	57.3	67.8	72.9	68.0	65.5	51.5	34.8	26.9	47.9
1895,	23.2	19.5	31.2	45.6	59.7	69.1	67.6	69.7	64.1	45.6	40.7	30.5	47.2
1896,	20.7	25.0	29.2	48.3	61.1	65.0	71.3	68.8	59.5	47.0	42.2	25.6	47.0
1897,	24.7	25.4	33.1	47.1	56.8	62.0	71.6	66.8	60.1	49.8	36.2	28.3	46.8
1898,	21.8	26.1	39.7	42.4	55.3	66.1	70.9	70.2	63.6	51.1	37.5	25.9	47.5
Mean,	23.6	25.1	33.1	45.7	57.1	66.3	69.6	68.6	60.9	49.2	38.1	27.5	47.1

* Records incomplete.

Range of Temperature (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890, ...	57.0	54.5	69.0	57.5	48.5	47.5	54.0	47.0	52.0	52.0	51.0	48.5	100.5
1891, ...	52.5	60.0	57.5	61.5	62.0	60.0	48.5	47.5	55.5	69.0	60.5	51.5	100.0
1892, ...	66.5	53.5	54.5	58.5	56.0	54.0	52.0	44.0	49.0	54.5	53.0	47.0	104.5
1893, ...	63.0	54.5	48.0	48.5	57.0	52.5	49.5	57.0	51.0	57.0	52.0	64.0	109.0
1894, ...	52.0	66.0	56.0	63.0	56.0	55.5	50.0	54.0	56.0	43.0	55.0	55.0	115.0
1895, ...	50.0	55.0	44.0	56.0	62.5	51.0	54.0	52.0	64.0	51.0	57.0	68.0	105.0
1896, ...	53.0	67.0	52.0	67.5	62.5	51.0	41.0	55.0	57.5	49.0	54.0	62.0	111.0
1897, ...	51.0	59.0	60.5	60.0	48.0	47.5	36.0	43.0	59.5	63.5	58.0	62.5	102.5
1898, ...	65.5	73.0	45.5	54.0	46.0	50.0*	56.5	46.5	58.5	59.5	56.0	60.0	115.5
Mean, ...	56.7	60.3	54.1	58.4	55.4	52.2	48.0	49.6	55.9	55.4	55.2	57.7	107.0

* Records incomplete.

Maximum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890,	61.5	57.5	62.5	79.5	80.0	88.0	94.0	88.5	80.5	78.0	62.5	43.5	94.0
1891,	52.0	54.0	56.5	79.5	87.0	94.0	90.0	92.5	91.5	89.0	64.0	60.5	94.0
1892,	57.0	46.5	60.5	78.5	84.0	95.0	94.0	94.0	80.0	77.5	67.0	46.0	95.0
1893,	50.0	50.0	52.0	67.5	87.0	94.0	90.5	96.0	81.0	80.0	63.0	52.0	96.0
1894,	53.0	49.0	73.0	79.0	85.0	93.0	98.0	91.0	91.0	75.0	65.0	51.0	98.0
1895,	45.5	45.0	49.0	81.0	92.0	95.0	90.0	90.0	97.0	71.0	72.0	65.0	97.0
1896,	41.0	53.0	57.0	88.5	94.5	90.0	91.0	97.0	88.5	72.0	69.0	52.5	97.0
1897,	51.0	48.0	59.0	80.5	79.5	85.5	91.0	85.0	91.5	84.0	63.0	59.0	91.5
1898,	50.0	54.0	60.0	71.0	78.5	89.5	96.5	91.0	93.0	86.5	62.0	48.0	96.5
Mean maximum,	51.2	50.8	58.8	78.3	85.3	91.6	92.8	91.7	88.2	79.2	65.3	53.1	95.4

* Records incomplete.

Minimum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890,	4.5	3.0	—6.5	22.0	31.5	40.5	40.0	41.5	28.5	26.0	11.5	—5.0	—6.5
1891,	—0.5	—6.0	—1.0	18.0	25.0	34.0	41.5	45.0	36.0	20.0	3.5	9.0	—6.0
1892,	—9.5	—7.0	6.0	20.5	28.0	41.0	42.0	50.0	31.0	23.0	14.0	—1.0	—9.5
1893,	—13.0	—4.5	4.0	19.0	30.0	41.5	41.0	39.0	30.0	23.0	11.0	—12.0	—13.0
1894,	1.0	—17.0	17.0	16.0	29.0	37.5	48.0	37.0	35.0	32.0	10.0	—4.0	—17.0
1895,	—4.5	—10.0	5.0	25.0	29.5	44.0	46.0	38.0	33.0	20.0	15.0	—3.0	—10.0
1896,	—12.0	—14.0	5.0	21.0	32.0	39.0	50.0	42.0	31.0	23.0	15.0	—9.5	—14.0
1897,	0.0	—11.0	—1.5	20.5	31.5	38.0	55.0	42.0	32.0	20.5	5.0	—3.5	—11.0
1898,	—15.5	—19.0	14.5	17.0	32.5	39.5	40.0	44.5	34.5	27.0	6.0	—12.0	—19.0
Mean minimum,	—5.5	—9.5	4.7	19.9	29.9	39.4	44.8	42.1	32.3	23.8	10.1	—4.6	—11.8

* Records incomplete.

Mean Dew Point (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889,	26.3	21.2	30.4	43.8	52.8	61.1	62.7	59.5	56.9	39.4	38.3	30.9	43.6
1890,	23.8	25.2	26.5	35.6	58.0	57.9	61.5	57.2	55.8	41.0	29.7	14.7	40.6
1891,	20.7	21.7	22.6	36.3	44.6	57.0	58.5	62.4	58.1	40.6	30.4	28.2	40.1
1892,	18.8	20.9	21.5	33.0	44.9	62.3	60.9	62.1	51.9	41.0	32.1	20.5	39.2
1893,	13.9	17.3	24.0	31.4	45.7	58.3	58.8	59.9	49.1	44.2	29.9	21.9	37.9
1894,	21.6	17.9	31.1	34.2	52.6	57.9	62.4	58.6	56.2	44.6	27.3	22.3	40.5
1895,	19.2	17.1	26.2	35.8	48.7	59.6	59.3	60.4	54.8	35.4	34.4	23.6	39.5
1896,	14.3	22.0	25.6	35.9	48.3	53.9	62.4	61.7	54.5	42.4	37.7	19.6	39.9
1897,	18.0	18.1	26.9	35.7	48.0	53.3	64.6	59.7	52.7	39.0	31.8	24.2	39.6
1898,	18.4	21.8	30.5	34.2	48.8	59.3	64.6	64.6	56.9	46.6	32.7	20.8	41.6
Mean,	19.5	20.3	26.5	35.6	49.2	58.1	61.6	60.6	54.7	41.4	32.4	22.7	40.2

Mean Relative Humidity.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889,	79.0	90.0	75.0	78.3	73.8	79.1	78.2	80.4	83.3	75.7	75.4	75.2	78.6
1890,	68.2	74.8	77.3	64.7	67.1	71.3	70.1	74.9	80.9	68.2	67.8	67.2	71.1
1891,	72.2	69.4	63.7	60.1	59.3	65.3	66.1	70.3	72.1	65.5	68.7	68.7	66.8
1892,	73.7	72.8	64.1	54.5	60.3	68.9	65.6	74.9	70.7	65.5	71.0	70.3	67.7
1893,	80.2	74.7	71.4	64.8	66.0	71.1	64.8	70.7	72.8	67.0	68.8	80.9	71.1
1894,	78.8	77.5	67.5	60.5	65.8	68.1	68.2	69.9	74.4	82.7	70.8	79.0	71.9
1895,	82.5	83.9	80.6	68.1	65.0	68.5	72.7	72.7	73.7	69.2	80.5	75.4	74.4
1896,	73.3	87.5	85.3	62.0	62.5	67.3	73.1	79.9	84.0	85.1	82.3	79.8	76.9
1897,	77.1	75.7	78.9	68.2	71.5	73.3	80.1	79.6	76.6	68.7	83.2	83.9	76.4
1898,	85.2	83.1	72.6	72.1	78.4	77.1	79.3	82.1	80.0	83.6	83.4	80.2	79.8
Mean,	77.0	78.9	73.6	65.3	67.0	71.0	71.8	75.5	76.6	73.2	75.2	76.1	73.5

Mean Per Cent. of Cloudiness, from Tri-daily Observations.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	55	40	63	55	42	53	54	43	65	60	68	61	55
1890, ...	52	66	66	50	59	50	56	57	59	64	47	53	57
1891, ...	61	59	55	49	54	47	54	58	50	54	50	51	53
1892, ...	63	55	45	42	66	50	35	53	29	46	58	45	49
1893, ...	52	57	46	55	55	58	44	45	46	40	49	54	50
1894, ...	53	53	55	53	52	54	50	44	53	44	50	44	50
1895, ...	51	39	55	54	46	48	58	44	42	42	61	45	49
1896, ...	43	63	54	39	40	47	50	40	52	63	59	42	49
1897, ...	46	51	56	46	47	47	64	42	39	39	71	68	51
1898, ...	66	64	53	68	65	57	53	60	48	62	60	66	60
Mean, ...	54.2	54.7	54.8	51.1	52.6	51.1	51.8	48.6	48.3	51.4	57.3	52.9	52.4

Hours of Bright Sunshine by Sun Thermometer.

YEAR.	January	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Possible hours, . . .	294	296	371	402	453	457	462	429	373	341	293	283	4,454
1889, ...	134	183	138	191	270	277	182	194	120	129	84	108	2,010
1890, ...	112	131	160	245	225	264	289	199	166	129	143	131	2,194
1891, ...	126	124	195	240	226	248	222	204	224	150	141	143	2,245
1892, ...	128	138	196	244	183	218	287	201	234	178	101	144	2,261
1893, ...	130	111	172	166	188	209	259	225	185	182	133	112	2,072
1894, ...	120	121	150	174	208	180	237	237	176	160	128	159	2,051
1895, ...	158	187	172	188	243	246	192	251	254	197	111	169	2,363
1896, ...	157	168	210	258	297	263	260	254	189	115	105	172	2,448
1897, ...	144	154	188	239	236	248	214	274	221	209	90	108	2,325
1898, ...	132	138	200	168	200	270	236	201	218	157	105	113	2,159
Mean, ...	134	145	178	211	228	242	238	224	199	161	114	136	2,212
Mean per cent., . .	45.7	49.0	48.0	52.5	50.3	53.0	51.5	52.2	53.4	47.2	39.0	48.1	49.7

Precipitation (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	3.50*	1.46*	1.02*	3.22*	4.18*	5.40*	10.52	2.72	3.17	4.58	6.04	3.57	49.38
1890, ...	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891, ...	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892, ...	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893, ...	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894, ...	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895, ...	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896, ...	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897, ...	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898, ...	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
Mean, . . .	3.93	3.13	3.12	2.76	4.15	3.73	5.74	4.05	3.73	4.00	4.10	3.56	46.00

* Kindly furnished by Miss S. C. Snell.

Departures from Monthly Normals.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	—.43	—1.67	—2.10	.46	.03	1.67	4.78	—1.33	—.56	.58	1.94	.01	3.38
1890, . .	—1.32	1.07	2.25	—1.03	1.24	—2.20	—.11	.83	2.12	3.13	—2.78	—.70	2.50
1891, . .	2.82	1.10	—.13	—.10	—2.18	1.02	—.46	.13	—1.07	—1.06	—1.11	1.84	.80
1892, . .	1.92	—1.23	—.72	—2.00	2.13	—.27	—1.33	2.42	—1.57	—3.34	.88	—2.55	—5.66
1893, . .	—.60	2.62	.54	1.65	.87	—.41	—3.15	—.56	—.91	.88	—1.29	1.30	.94
1894, . .	—1.77	—1.39	—1.35	—.93	—.15	—.60	—4.19	—3.74	.90	.85	—.96	—.03	—13.36
1895, . .	—.06	—2.08	—.41	2.80	—2.08	—.97	—1.87	—.59	1.31	.77	1.26	.38	—1.54
1896, . .	—2.86	1.54	2.99	—1.44	—1.57	—1.16	—.78	—.21	1.68	—.77	—1.07	—2.69	—6.34
1897, . .	—.93	—.61	.41	—.34	.23	2.92	8.77	.24	—1.79	—3.27	1.75	3.67	11.05
1898, . .	3.22	.67	—1.49	.97	1.46	—.04	—1.65	2.05	—.08	2.27	1.38	—1.26	8.25

Wind Movement (in Miles).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	5,101	4,828	7,068	5,648	4,056	4,056	4,032	2,811	4,310	4,762	2,589	4,445	53,706
1890, ...	4,914	4,616	5,395	5,020	5,284	3,776	3,976	4,116	3,507	4,143	4,228	5,673	54,648
1891, ...	4,954	4,759	6,261	5,484	4,610	3,713	3,907	3,324	3,201	4,319	5,215	5,465	55,212
1892, ...	5,059	3,438	7,046	5,370	5,056	4,500	3,365	3,390	3,672	4,071	5,231	4,522	54,720
1893, ...	4,056	5,242	5,757	5,384	4,833	3,572	3,640	4,126	3,508	4,198	4,179	3,916	52,411
1894, ...	4,193	4,865	4,406	4,105	2,180	1,838	1,109	1,920	1,414	2,540	4,179	3,508	36,257
1895, ...	2,896	3,920	4,360	4,098	4,071	3,050	2,934	3,397	3,444	5,029	4,156	5,506	46,861
1896, ...	4,943	6,445	8,182	4,674	4,838	3,926	4,048	2,968	4,686	4,544	4,654	5,290	59,198
1897, ...	5,501	4,493	5,363	5,523	5,603	4,208	4,007	3,452	3,506	3,938	4,558	4,068	54,220
1898, ...	3,494	3,699	3,864	5,477	4,769	4,162	3,377	3,111	2,787	3,999	4,856	4,830	48,425
Mean, ...	4,511	4,630	5,770	5,078	4,530	3,680	3,439	3,262	3,404	4,154	4,385	4,722	51,566

Maximum Wind Pressure (in Pounds per Square Foot).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	26.00	24.0	16.75	15.50	9.00	11.50	10.00	6.5	9.75	12.25	14.50	29.0	29.00
1890, ...	27.75	17.5	13.50	11.50	16.50	10.00	9.25	13.0	5.00	11.00	9.50	24.5	27.75
1891, ...	16.25	13.5	10.50	14.00	10.75	10.50	4.50	2.5	4.00	9.50	15.75	14.0	16.25
1892, ...	10.50	11.5	20.50	16.75	15.75	20.50	11.50	7.5	15.50	12.50	16.00	13.5	20.50
1893, ...	12.00	20.0	18.50	24.50	24.75	9.00	13.00	37.5	14.50	23.00	14.00	18.5	37.50
1894, ...	20.00	22.5	11.50	15.50	14.50	14.00	9.50	9.5	13.00	10.00	18.00	15.0	22.50
1895, ...	13.00	25.0	20.00	10.00	7.00	8.00	8.00	5.5	43.00	14.00	22.00	24.0	43.00
1896, ...	15.00	24.5	19.00	18.00	25.00	7.75	8.50	12.5	19.00	12.00	15.00	12.0	25.00
1897, ...	18.50	10.0	13.50	14.00	22.00	7.00	12.00	14.0	20.00	11.50	20.00	12.0	22.00
1898, ...	22.50	15.5	15.50	10.00	18.00	8.50	17.50	13.0	30.50	12.00	19.00	28.0	30.50
Maximum, . .	27.75	25.0	20.50	24.50	25.00	20.50	17.50	37.5	43.00	23.00	22.00	29.0	43.00

Maximum Velocity of Wind (in Miles per Hour).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	72	69	58	56	42	48	45	36	44	50	54	76	76
1890, ...	74	59	52	48	57	45	43	51	32	47	44	70	74
1891, ...	57	52	46	53	46	46	30	23	28	44	56	53	57
1892, ...	46	48	64	58	56	64	48	39	56	50	57	52	64
1893, ...	49	63	61	70	70	42	51	87	54	68	53	61	87
1894, ...	63	67	48	56	54	53	44	44	51	45	60	55	67
1895, ...	51	71	63	45	37	40	40	33	93	53	66	69	93
1896, ...	55	70	62	60	71	39	41	50	62	49	55	49	71
1897, ...	61	45	52	53	66	37	49	53	63	48	63	49	66
1898, ...	67	56	56	45	60	41	59	51	78	49	62	75	78

Snow, Frost and Weather.

YEAR.	Last Snow.	First Snow.	Total Snowfall (Inches).	Last Frost.	First Frost.	Number of Days .01 Precipitation.	Number of Clear Days.	Number of Fair Days.	Number of Cloudy Days.
1889,	April 2,	Oct. 13,	26.0	May 26,	Sept. 21,	119	94	110	161
1890,	April 8,	Oct. 19,	43.5	May 12,	Sept. 25,	141	137	105	123
1891,	May 5,	Nov. 26,	54.2	May 19,	Oct. 12,	112	145	103	117
1892,	April 10,	Nov. 5,	42.5	May 10,	Sept. 30,	108	123	109	134
1893,	April 21,	Nov. 4,	74.3	May 8,	Sept. 3,	143	101	96	168
1894,	April 12,	Nov. 5,	71.5	May 22,	Aug. 22,	125	107	83	175
1895,	April 3,	Oct. 20,	61.0	May 17,	Aug. 22,	119	118	110	137
1896,	April 7,	Nov. 14,	44.0	May 1,	Sept. 24,	108	132	102	132
1897,	April 27,	Nov. 12,	52.8	May 8,	Sept. 22,	127	108	109	148
1898,	April 6,	Nov. 24,	69.5	April 27,	Sept. 21,	135	78	138	149

Summary for the Ten Years 1889–98.

Barometer (Pressure in Inches).

Maximum, reduced to freezing, Feb. 26, 1889, 11 A.M.,	30.650
Minimum, reduced to freezing, Feb. 8, 1895, 7 A.M.,	28.240
Maximum, reduced to freezing and sea level, Feb. 26, 1889, 11 A.M.,	30.970
Minimum, reduced to freezing and sea level, Feb. 8, 1895, 7 A.M.,	28.560
Mean,	30.029
Total range,	2.410
Greatest annual range, 1895,	2.270
Least annual range, 1892,	1.650
Mean annual range,	1.920
Greatest monthly range, January, 1891,	1.930
Least monthly range, July, 1895,	.510
Mean monthly range,	1.090

Air Temperature (in Degrees F.).

Highest, July 20, 1894, 5 P.M.,	98.000
Lowest, Feb. 3, 1898, 6 A.M.,	—19.000
Mean,	47.100
Total range,	117.000
Greatest annual range, 1898,	115.500
Least annual range, 1891,	100.000
Mean annual range,	107.000
Greatest monthly range, February, 1898,	73.000
Least monthly range, July, 1897,	36.000
Mean monthly range,	54.900
Greatest daily range, Feb. 18, 1892,	52.500
Least daily range, April 5, 1898,	2.500
Mean daily range,	22.100

Humidity.

Mean dew point,	40.200
Mean force of vapor,	.430
Mean relative humidity,	73.500

Precipitation (in Inches).

Total rain or melted snow,	460.000
Total snowfall,	539.300
Greatest annual precipitation, 1897,	57.050
Least annual precipitation, 1894,	32.640
Mean annual precipitation,	46.000
Greatest monthly precipitation, July, 1897,	14.510
Least monthly precipitation, October, 1892,	.660
Mean monthly precipitation,	3.830

Greatest in twenty-four hours, July 12-13, 1897,	5.650
Greatest in one hour, July 30, 1898,	1.500
Unusual rains: 1889, June 15, 2.10 inches in four hours; 1896, July 7, 1.10 inches in thirty minutes; 1897, June 9, 4.08 inches in twenty hours; July 13–14, 8 inches in forty-four hours; 1898, July 30, 2.65 inches in two hours; September 10, .95 inch in twenty minutes. Number of days on which .01 inch or more rain or melted snow fell,	1,241.000

Wind (in Miles).

Total movement,	515,638
Greatest annual movement, 1896,	59,198
Least annual movement, 1894,	36,257
Mean annual movement,	51,566
Greatest monthly movement, March, 1896,	8,182
Least monthly movement, July, 1894,	1,109
Mean monthly movement,	4,297
Greatest daily movement, Nov. 27, 1898,	675
Least daily movement, Sept. 29, 1894, and March 7, 1895,	–
Mean daily movement,	141
Maximum pressure per square foot, 43 pounds, = 93 inches per hour, Sept. 11, 1895, 3 P.M.	

Weather.

Mean cloudiness observed,	52.40 per cent.
Total cloudiness by the sun thermometer,	22,400 = 50.30 per cent.
Number hours bright sunshine recorded,	22,120 = 49.70 per cent.
Number of clear days,	1,143
Number of fair days,	1,065
Number of cloudy days,	1,444

Gales of 75 or more miles per hour: 1889, Dec. 26, 76, N.W.; 1893, Aug. 29, 87, S.W.; 1895, Sept. 11, 93, N.E.; 1898, Sept. 7, 78, S.W.; Dec. 4, 75, E.S.E.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of experimentation carried on by this division have been kept strictly within the limits of practical horticulture, devoting especial attention to the growth of common fruit and garden crops, and their protection from insect and fungous pests.

New varieties of fruits, vegetables, ornamental trees, shrubs and plants of promise have been obtained and tested under varying conditions, and many new seedlings produced. For the work of testing varieties a large collection of standard varieties from different sections of the country have been obtained, that, when a new variety is to be tested, careful comparison may be made under conditions where the exact value of standard varieties is known. As far as possible, new varieties are grown under many varying conditions, and very careful inquiry is made of their behavior in many localities.

Previous reports have given the number of varieties of the different kinds of fruits, vegetables, flowers, etc., under experiment, to which have been added the following number of new varieties the past season: apples, four; pears, five; plums (domestic), three; plums (Japanese), seven; plums (American), seven; peaches, five; quinces, two; cherries, four; grapes, four, besides numerous seedlings; blackberries, three; red raspberries, two, and a large collection of seedlings; strawberries, twenty, and many seedlings; chestnuts (Japanese, Spanish and native varieties), eight; walnuts (species and varieties), six; several new hardy ornamental trees, shrubs and plants, and many new varieties of ornamental plants for the greenhouse and summer outdoor decoration.

Immediate results are constantly called for in the case of widely advertised new varieties, but such results can be obtained only under a series of seasons and varying conditions of growth. This work of testing varieties is begun at once upon introduction, and is hastened by all possible means.

The experiments under way, in addition to the testing of varieties, are as follows: —

1. The girdling of the grape vine for profit.
2. Spraying fruit trees when in bloom, to change the bearing year.
3. Spraying peach trees during the winter with lime, to protect the flower buds from winter-killing.
4. The use of dilute copper sulfate in place of the ammoniacal carbonate of copper.
5. The testing of insecticides and fungicides.
6. The testing of spraying apparatus.
7. The use of clear kerosene and kerosene and water for the destruction of scale insects and aphides.
8. The protection of young fruit trees from mice.
9. Various kinds of grafting wax.
10. Various methods of grafting.
11. Whole roots and piece roots in apple root-grafting.
12. Different kinds of stocks for the pear.
13. Growing seedling fruit-tree stocks.
14. The use of hydrocyanic acid gas for the destruction of insects under glass.
15. Turf culture *v.* cultivation in growing apples.
16. Amount and kinds of fertilizers needed for best growth of fruits.
17. Green manuring for orchards.
18. Comparative hardiness of varieties of Japanese plums.
19. Growth of lettuce under glass.
20. Growth of tomatoes under glass.

Assistance has been given many horticulturists by visiting their places or answering inquiries by letter, which takes a large share of the time of the head of the division. Assistance has also been given in many places in planning ornamental planting of home and public grounds.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Since my last report the entomological work of the station has proceeded along its usual lines. A large amount of correspondence has been carried on, and many letters of inquiry from residents of this State have been answered. Believing, however, that the opportunities afforded by this division of the experiment station were either not known of by many, or that the way in which to make use of them was not understood, the following note on the work was prepared : —

Free Aid for the People.

Prevention of Loss by Injurious Insects.

The attacks of injurious insects probably cause the loss of several millions of dollars in Massachusetts alone each year. This has not always been the case, but insects are becoming more abundant and consequently more destructive. Much of this destruction, however, could be either in part or wholly prevented if the proper methods of treatment were made use of, and that this is not more frequently done is very unfortunate. It is probable that the reason for the apparent negligence in this regard is due to ignorance as to what the insect is in each particular case, and what to do to prevent its ravages. It is this very uncertainty which results in nothing being done in most cases.

In order to provide this information for residents of the State, the entomological division of the Hatch Experiment Station at Amherst offers its services without charge to all who may desire them. To obtain this assistance, write to the entomologist, Hatch Experiment Station at Amherst, Mass., describing the trouble, and also, if possible, send samples of the injury and the insect causing it, and attention will at once be given to the matter.

As the Hatch Experiment Station of Massachusetts is supported in part by State appropriation, such a use of its facilities by the

people of the State is not only justifiable but most desirable, for it was established for just that purpose; and no one who incurs loss by insect ravages can excuse himself for that loss except on the ground of ignorance that such assistance can be obtained.

Over eight hundred of these circulars were sent out to the newspapers, granges and other organizations of the State, with the request that the facts contained therein be given the greatest publicity. As these slips were not circulated till December, 1899, it is not possible to ascertain the results, but a considerable increase in the already large correspondence is anticipated during the coming year.

Last June my assistant, Mr. R. A. Cooley, was appointed professor of zoölogy and entomology at the Montana State College. Mr. Cooley is a careful and thorough investigator, and proved himself a very efficient and valuable assistant to me. The loss of his services rendered necessary the appointment of some one to take his place. As it was advisable for many reasons to obtain a man of large experience, Dr. H. T. Fernald of Pennsylvania, for nine years professor of zoölogy and entomology at the Pennsylvania State College, and for the past two years State entomologist of Pennsylvania, was elected associate entomologist, to take the place made vacant by the resignation of Mr. Cooley.

The San José Scale.

The San José scale is now known to occur in injurious abundance at more than thirty different places in Massachusetts, — in fact, it may be said to be generally distributed over the State. It has probably been introduced from several other States, as there is nothing except the objections of purchasers to prevent its being brought in on every plant purchased. Its presence, however, and the serious destruction it causes, have led a number of States to pass laws excluding all stock from outside their borders unless accompanied by an authorized certificate that the stock had been inspected and no scale found. This action was most inconvenient for Massachusetts nurserymen, who were often thus prevented from filling orders to go to States having such laws. To meet this difficulty, the committee of the trustees

of the college, in charge of the experiment station, authorized the entomological division of the station to inspect nurseries when requested to do so by their owners, and to give authorized certificates where no scale is found, charging for this work only the actual expenses incurred. This action was not a required one, and was taken solely for the purpose of accommodating nurserymen, many of whom have already shown their appreciation of the arrangement and have availed themselves of the opportunity thus afforded them.

Bulletin on Chionaspis.

On the 10th of August, 1899, the work of Mr. R. A. Cooley on the different species of *Chionaspis* and *Hemichionaspis* was published in a special bulletin of the station. This bulletin, treating of many of the important scale insects which have recently attracted so much attention because of the injury they do to fruit and other trees, was fully illustrated, and has received high commendation not only in this country but also in Europe.

The Grass Thrips.

Studies on the grass thrips have been continued during the year by Mr. W. E. Hinds, one of the senior students, with most satisfactory results, and are published as an appendix to the college catalogue. As these studies are largely technical, such of the facts as have an economic bearing will also be published in a bulletin for the use of the farmers of the State.

The Clover-head Beetle.

Work on the clover-head beetle (*Phytonomus nigrirostris*) has been continued during the year by Mr. C. M. Walker, and the results are nearly ready for publication. Its life history has been nearly completed, and the best methods of treatment are being investigated. This work will be published as soon as completed.

Raupenleim.

This substance, which is of such value for banding trees liable to the attacks of the canker worms, tussock moth, etc., has heretofore been manufactured by a secret process in Ger-

many. During the past year the chemist of the Gypsy Moth Commission, Mr. F. J. Smith, made experiments at the chemical laboratory of the insectary, to determine its composition. These experiments proved very successful, and in consequence raupenleim can now be manufactured in this country at a low cost. This one discovery has been estimated as worth half a million of dollars to the farmers and fruit growers of the United States.

The Gypsy Moth.

The work of exterminating the gypsy moth, with which I have been connected since 1891, has been carried on during the past year with marked success, and the insect has been reduced to such an extent over almost the entire territory that one who has kept in close touch with the field work for several years past cannot fail to be impressed by the great gain that has been made towards the extermination of this pest.

There is no longer any question, in the minds of those who have made a careful personal investigation of the work throughout the infested territory, that the gypsy moth can be exterminated. Nearly all of the prominent economic entomologists of this country have inspected the work with great care, and have become fully convinced that extermination is possible, if the Legislature each year promptly grants the full appropriation asked for this purpose by the gypsy moth committee. The entire responsibility now rests with the Legislature.

The Brown-tail Moth.

This insect has now become widely distributed in the eastern part of this State, and even extends into New Hampshire ; it is therefore believed to be impossible to exterminate this pest with any appropriations that the two States in which it now occurs would be likely to make. When attention was first called to this insect, in the spring of 1897, the matter was laid before Governor Wolcott, who sent a message to the Legislature recommending an appropriation of $10,000 for the extermination of the pest, which then occurred only in a very limited area. It was believed that this amount

would be sufficient to stamp out the insect. The Legislature, however, refused to make any appropriation for this purpose, and the inevitable results followed.

In consideration of the failure of the Legislature to prevent the spread of the brown-tail moth over the country, the gypsy moth committee have authorized me, with the assistance of those associated with me, to "collect such information, both in this country and Europe, in regard to the brown-tail moth, and make such experiments with the insect as may be useful to the committee in future dealing with the creature and necessary for the proper enlightenment of the public on the subject, with a view to publish the said information, if it may appear desirable."

In accordance with this action of the gypsy moth committee a large amount of time has already been spent on this work, but it is far from being completed, and it is impossible at present to say just when the work will be ready for publication.

Monograph of the Pyralidæ.

I have been engaged for many years in a critical study of the microlepidoptera of North America, and have already published several monographs on certain families of these insects. I am now at work on a monograph of the Pyralidæ, which will probably be ready for publication some time this year.

The Card Catalogue.

The card catalogue of insects now contains over forty thousand cards, and is continually growing in size, as constant additions are made to it from the new journals and other entomological publications as they are received. Only those insects occurring in North America have been catalogued in the past, but the literature of the scale insects (Coccidæ) of all countries is now being added. This is rendered necessary, as these insects are being imported into our country from different parts of the world without restriction in any State except California.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, F. W. MOSSMAN, B. K. JONES, P. H. SMITH, JR.

PART I. — LABORATORY WORK.

Outline of Year's Work.

PART II. — FEEDING EXPERIMENTS AND DAIRY STUDIES.

PART I.

EXTENT OF CHEMICAL WORK.

The work of the chemical laboratory connected with this department has materially increased during the past year, notwithstanding the prolonged illness of Dr. Lindsey, which necessitated a temporary rearrangement of the staff, leaving the bulk of the analytical work to be carried on by two assistants.

There have been sent in for examination 167 samples of water, 144 of milk, 193 of cream, 36 of pure and process butter, 25 of oleomargarine, 147 of feed stuffs and 52 of miscellaneous substances.

In connection with experiments by this and other divisions of the station there have been analyzed 62 samples of milk, 54 of butter and 429 of fodders and feed stuffs.

In addition to the above, 748 samples of commercial concentrated feed stuffs have been collected under the provision

of the feed law, of which 736 samples have been tested, either individually or in composite. This makes a total of 2,045 substances analyzed during the year, as against 1,875 last year and 1,147 in the year previous. There have also been carried on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

Character of Chemical Work.

Water. — Sanitary examinations of water have been carried out, as in previous years, according to the Wanklyn process, to determine its general fitness for domestic purposes and for the use of live stock.

Persons whose water supply is other than that of a city or town system should use every possible means to guard it against pollution arising from sinks, vaults and stables, or from the entrance of surface water and animal and vegetable matter. The latter, while not in itself highly injurious to health, is objectionable, as it favors the rapid propagation of bacteria and other micro-organisms. The detection of specific disease germs in water is, however, not a function of the chemist, but of the bacteriologist.

Frequent cases of poisoning result from conducting drinking water through lead pipe, and such a practice cannot be too severely condemned, for the poison, once assimilated, is very difficult to remove from the system. At least five samples examined during the past year have shown its presence. Soft waters as a rule have a much greater solvent action upon lead than hard waters. Wells and springs ought to be thoroughly cleaned at regular intervals.

It is of great importance that the utmost care be exercised in taking the sample for analysis, otherwise the chemical examination, conducted under the most careful and exacting conditions, is of little or no value. The quantity necessary is two to three quarts, collected in a thoroughly cleaned and well-rinsed glass bottle, stoppered with a new cork, over which is to be tied a clean piece of cotton cloth. An air space of about one inch should be left between cork and liquid, to allow for expansion. In case of pond water, the sample should be taken from below the surface, being care-

ful to avoid the surface scum and the sediment at the bottom. The chemist's report upon the character of the water must necessarily be a matter of judgment, based on the analysis and the information furnished by the party sending the sample. Accurate replies to the following questions are necessary to a complete understanding of each case, and are for the interest of the person sending the water: —

1. Sources, whether from spring, stream, pond, reservoir or well.
2. Character of soil in which located.
3. Distance from any possible source of pollution, and character of the same.
4. Kind of pipe used for conducting the water.

Ship samples at once by express, charges prepaid. In making the report of an analysis a printed form is used, which explains the results so as to be readily understood by any one.

The examination of mineral or spring waters for which medicinal properties are claimed, or those intended for commercial purposes, does not fall within the scope of our duties.

Milk. — The samples sent in show a wide variation both in solids and fat, a considerable number falling below the Massachusetts legal standard,* indicating a need on the part of certain milkmen and others of introducing better stock and disposing of inferior animals.

In taking a sample for analysis, mix the entire milking by pouring three or four times from one vessel to another, and immediately fill a pint bottle. Mark each sample, stating kind of milk (whole, skim or buttermilk) and the tests desired, together with the name and address of the shipper; the package to be marked "*Immediate Delivery*," and sent by express, prepaid. Samples sent from a considerable distance should be treated with four drops of forty per cent. formaldehyde (obtained at any apothecary's), to insure the preservation of the sample.

Cream. — Everything said in regard to the sampling and shipping of milk applies equally well to cream.

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* In the months of October, November, December, January, February and March, 13 per cent. solids and 3.7 per cent. fat are required, but during the remainder of the year only 12 per cent. solids and 3 per cent. fat.

Butter. — In connection with the feeding experiments conducted at the barn last season many samples of butter were analyzed, and very thorough examinations of the butter fat, both in regard to its chemical composition and physical properties, were made.

"Renovated" or "process" butter having become of considerable prominence in the market, a law was passed by the last Legislature forbidding its sale except when plainly marked, in one-half inch type, "Renovated butter." Several samples have been identified in this laboratory by means of a microscopical examination, general characteristics of the melted fat and curd, together with the Reichert number; and a much larger number of oleomargarines have been identified by the same methods.

Cattle Feeds. — The feed law passed by the State Legislature, which took effect in July, 1897, is apparently meeting with good success. The work is carried out by this department, the assistants making a semi-annual canvass of the State, taking samples of all the prominent concentrated feed stuffs. The samples so collected are carefully analyzed, and the results published in bulletins from time to time. The purpose of this work is to exclude poor and adulterated feeds, and to maintain products of a uniform grade.

The effect of the law on the quality of cotton seed meal has been very marked. In the earlier collections inferior meals were common, but during the present season but few were found, and the average protein content is many per cent. higher. Low-grade wheat feeds and oat feeds of unknown manufacture still remain in the market, and probably will to some extent until a guarantee is required on all feeds and power given to enforce the same.

Part II.

Feeding Experiments and Dairy Studies.

An investigation was instituted last season to ascertain the effect produced on the quantity and quality of butter fat by feeding ground flax-seed meal containing thirty-six per cent. of oil, as compared with a normal linseed ration.

Following this, a long series of feeding experiments was begun, the object being to demonstrate, if possible, the effect of each of the food components, protein, fat and carbohydrates, as found in different feed stuffs, — linseed meal, gluten meal, cotton seed meal, etc., — upon the composition and physical characteristics of the resulting butter fat. In each case the experiment was compared with a standard ration supposed to be without special effect on the butter fat. It is evident that such a task involves a large amount of careful and long-continued work, but as soon as positive results are obtained they will be published.

Digestion Experiments.

Digestion experiments were conducted last winter and spring in the same careful manner as in previous years, using two or three sheep in each trial. The grains fed were oat feed, Parson's $6 feed, four lots of "Bourbon" distillers' grains (brands X., XX., XXX. and XXXX.), rye distillers' grains, Cleveland flax meal and Chicago gluten meal.

The digestion coefficients, together with complete data, will be reported at a later date.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, SAMUEL W. WILEY.

Part I. — Report on Official Inspection of Commercial Fertilizers.

Part II. — Report on General Work in the Chemical Laboratory.

Part I. — Report on Official Inspection of Commercial Fertilizers and Agricultural Chemicals during the Season of 1899.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 67; of these, 38 have offices for the general distribution of their goods in Massachusetts, 10 in New York, 5 in Connecticut, 3 in Vermont, 3 in Rhode Island, 3 in Canada, 2 in Pennsylvania, 1 in Maine, 1 in New Jersey and 1 in Illinois.

Two hundred and ninety-one distinct brands of fertilizer, including chemicals, have been licensed in the State during the year.

Three hundred and eighty-four samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and sixty-two samples were analyzed at the close of November, 1899, representing 289 distinct brands of fertilizer. These analyses were published in three bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 59, March; No. 62, July; and No. 63, November, 1899.

The samples not already analyzed, together with others that may be collected before the first of May, 1900, will be examined with a view of being published in our spring bulletin.

During the season the inspector has caused samples to be taken in the towns and villages distributed throughout the State, and representing each county within the Commonwealth. Wherever more than one sample of a given brand has been collected in different parts of the State, a composite sample has been made up of equal weights of the several samples, and an analysis made of the homogeneous mixture. It is believed that an analysis of this nature more fairly represents the composition of the fertilizer than the analysis of any one sample.

It has not always been possible to secure a complete list of the samples licensed in the State; but as thorough a canvass as possible is annually made, varying more or less the towns to be visited from year to year, as seems advisable to the inspector. The methods of sampling are those laid down by our State laws for the regulation of the trade in commercial fertilizers.

For the readers' benefit the following abstract of the results of our analyses are here inserted: —

	1898.	1899.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee, .	5	16
Number with two elements above the highest guarantee, ...	17	27
Number with one element above the highest guarantee, ...	77	73
Number with three elements between the lowest and highest guarantee, .	85	88
Number with two elements between the lowest and highest guarantee, .	93	84
Number with one element between the lowest and highest guarantee, .	54	58
Number with two elements below the lowest guarantee, ...	19	19
Number with one element below the lowest guarantee, ...	90	68
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee, ...	5	7
Number with one element above the highest guarantee, ...	24	32
Number with two elements between the lowest and highest guarantee, .	25	20
Number with one element between the lowest and highest guarantee, .	17	27
Number with two elements below the lowest guarantee, ...	2	2
Number with one element below the lowest guarantee, ...	8	18
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee, ...	18	10
Number between lowest and highest guarantee, ...	23	16
Number below lowest guarantee, ...	15	10

A comparison of the above-stated results of our inspection with the results of 1898 shows, on the whole, a marked superiority in favor of the samples analyzed in 1899.

Wherever a discrepancy has arisen between the results of our analyses and the manufacturer's guarantee, it has been evident that imperfect mixing has been the cause, and not a desire of the manufacturer to place inferior goods on the market. It should be remembered, when purchasing fertilizers, that the responsibility of the manufacturer or dealer ends with furnishing an article corresponding in its composition with the lowest stated guarantee of each of the three essential elements of plant food.

From a careful scrutiny of the results of analyses published in the three bulletins during the year it becomes an easy matter for the farmer to intelligently select his fertilizers for the next year's consumption, always bearing in mind that the fertilizer costing the least per ton is not always the most

economical fertilizer to buy, but rather the one that will furnish the greatest amount of nitrogen, potassium oxide and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1898 and 1899 (Cents per Pound).

	1898.	1899.
Nitrogen in ammonia salts,	14.00	15.00
Nitrogen in nitrates,	13.00	12.50
Organic nitrogen in dry and fine ground fish, meat, blood and in high-grade fertilizers.	14.00	14.00
Organic nitrogen in fine bone and tankage,	13.50	14.00
Organic nitrogen in medium bone and tankage,	10.00	10.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.50	2.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

The cost of some of the leading forms of nitrogen shows an increase, as compared with the preceding year, 1898.

The above trade values are based on the market cost, during the six months preceding March, 1899, of standard raw materials which are largely used in the manufacture of compound fertilizers found in our markets. The following is a list of such materials: —

Sulfate of ammonia.
Azotine.
Cotton-seed meal.
Linseed meal.
Bone and tankage.
Dissolved bones.
Acid phosphate.
High-grade sulfate of potash.
Sulfate of potash and magnesia.
Sylvinite.
Nitrate of soda.
Dried blood.
Castor pomace.
Dry ground fish.
Dry ground meat.
Ground phosphate rock.
Refuse bone-black.
Muriate of potash.
Kainite.
Crude saltpetre.

How to use the table of trade values in calculating the approximate value of a fertilizer: Calculate the value of each of the three essential articles of plant food (nitrogen, phosphoric acid and potassium oxide, including the different forms of each wherever different forms are recognized in the table) in one hundred pounds of the fertilizer, and multiply each product by twenty, to raise it to a ton basis. The sum of these values will give the total value of the fertilizer per ton at the principal places of distribution. An example will suffice to show how this calculation is made: —

Analysis of Fertilizer (Pounds in One Hundred Pounds of Fertilizer).

Nitrogen,	4
Soluble phosphoric acid,	8
Reverted phosphoric acid,	4
Insoluble phosphoric acid,	2
Potassium oxide (as sulfate),	10

	Value per One Hundred Pounds.	Value per Two Thousand Pounds.
Four pounds nitrogen, at 14 cents,	$0.56×20	=$11.20
Eight pounds soluble phosphoric acid, at 4½ cents,	.36×20	= 7.20
Four pounds reverted phosphoric acid, at 4 cents,	.16×20	= 3.20
Two pounds insoluble phosphoric acid, at 2 cents,	.04×20	= .80
Ten pounds potassium oxide, at 5 cents,	.50×20	= 10.00
Value per ton,		$32.40

The following table gives the average analysis of officially collected fertilizers for 1899: —

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.86	2.96	2.82	4.65	3.29	3.19	11.13	8.77	7.94	6.67	5.16	4.92
Ground bones,	5.23	2.99	2.63	-	5.58	18.61	24.19	22.53	5.58	6.67	-	-
Tankage,	5.75	4.88	4.41	-	4.99	14.49	18.66	16.33	5.83	-	-	-
Dissolved bone-black,	14.02	-	-	13.62	2.82	-	16.76	16.00	16.44	15.00	-	-
Wood ashes,	9.50	-	-	-	-	-	1.57	1.00	-	-	6.37	4.50
Cotton-hull ashes,	10.44	-	-	-	6.88	1.28	8.16	8.00	6.88	-	27.74	25.00
Cotton-seed meal,	7.79	7.09	6.96	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.65	15.71	15.36	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	1.94	21.00	20.60	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	1.17	-	-	-	-	-	-	-	-	-	48.42	48.95
Sulfate of potash and magnesia,	3.93	-	-	-	-	-	-	-	-	-	26.70	25.28
Muriate of potash,	1.43	-	-	-	-	-	-	-	-	-	49.68	50.27

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State of Massachusetts during the Past Year (May 1, 1899, to May 1, 1900), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.
- Fruit and Root Crop Special.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.
- Animal Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

The American Jadoo Co., Philadelphia, Pa.: —
- Jadoo Liquid.

Butchers' Rendering Co., Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

The East India Chemical Works (H. J. Baker & Bro., proprietors), New York, N. Y.: —
- Standard Un X Ld Fertilizer.
- Special Complete Strawberry Manure.
- Special Complete Potato Manure.
- Special Complete Cabbage Manure.
- Special Complete Grass and Lawn.
- Complete Manure for General Use.
- Pure Ground Raw Bone.
- Castor Pomace.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport, Conn.:—
- Complete Fertilizer.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash, H B.
- Fish Scrap No. 2, H B.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Special Fertilizers.
- Bowker's Potatoes and Vegetables.
- Bowker's Fish and Potash, Square Brand.
- Bowker's Potato Phosphate.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Essex County Fertilizer.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.

William E. Brightman, Tiverton, R. I.: —
- Brightman's Potato and Root Manure.
- Brightman's Phosphate.
- Brightman's Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- Bradley's Dry Ground Fish.
- Bradley's Strawberry Manure.
- Bradley's English Lawn Fertilizer.
- Bradley's New Method Fertilizer.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's Columbian Fish and Potash.

Bradley Fertilizer Co. — *Con.*
Bradley's Circle Brand Extra Fine-ground Bone with Potash.
Bradley's X. L. Phosphate.
Bradley's Potato Manure.
Bradley's Potato Fertilizer.
Bradley's Complete Manures.
Bradley's Fish and Potash.
Bradley's Corn Phosphate.
Bradley's Fine-ground Bone.
Ammoniated Bone Phosphate.
Breck's Lawn and Garden Dressing.
Dissolved Bone-black.
Sulfate of Potash.
Muriate of Potash.
Nitrate of Soda.
Kainite.

Joseph Breck & Sons., Boston, Mass.: —
Breck's Market-garden Manure.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
Church's B. Special Fertilizer.
Church's C. Standard Fertilizer.
Church's D. Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
Clark's Cove Bay State Fertilizer, G. G.
Clark's Cove King Philip Guano.
Clark's Cove White Oak Pure Ground Bone.
Clark's Cove Bay State Potato Manure.
Clark's Cove Great Planet Manure.
Clark's Cove Bay State Fertilizer.
Fish and Potash.
Potato Fertilizer.
High-grade Sulfate of Potash.
Muriate of Potash.
Nitrate of Soda.

Cleveland Dryer Co., Boston, Mass.: —
Cleveland Fertilizer.
Cleveland Potato Phosphate.
Cleveland Superphosphate.
Cleveland Grass Fertilizer.
Cleveland Corn and Grain Phosphate.

E. Frank Coe Co., New York, N. Y.: —
E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
E. Frank Coe's High-grade Potato Fertilizer.

E. Frank Coe Co. — *Con.*
E. Frank Coe's Bay State Phosphate.
E. Frank Coe's Fish Guano and Potash.
E. Frank Coe's Gold Brand Excelsior Guano.
E. Frank Coe's Tobacco and Onion Fertilizer.
E. Frank Coe's Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
Crocker's Vegetable Bone Superphosphate.
Crocker's Special Potato Manure.
Crocker's General Crop Phosphate.
Crocker's A. A. Complete Manure.
Crocker's Potato, Hop and Tobacco Phosphate.
Crocker's Ammoniated Wheat and Corn Phosphate.
Crocker's New Rival Ammoniated Superphosphate.
Crocker's New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Cumberland Phosphate.
Cumberland Potato Fertilizer.
Cumberland Concentrated Phosphate.
Cumberland Fertilizer.

Chas. M. Cox & Co, Boston, Mass.: —
Cotton-seed Meal.

L B. Darling Fertilizer Co., Pawtucket, R. I.: —
Potato and Root Crop.
Animal Fertilizer.
Blood, Bone and Potash.
Fine Bone,
Tobacco Grower.
Special Formula.
Nitrate of Soda.
Muriate of Potash.
Farm Favorite.

John C. Dow & Co., Boston, Mass.: —
Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Liquid Plant Food.
Imperial Liquid Grass Fertilizer.

Elbert & Gardner, New York, N. Y.: —
Cotton-seed Meal.

Wm. E. Fyfe & Co., Clinton, Mass.: —
Canada Wood Ashes.

T. H. Frowley, Brookline, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Garden Special.
Vegetable, Vine and Tobacco.
Northern Corn Special.
General Fertilizer.
Grass and Oats.

Thomas Hersom & Co., New Bedford, Mass.: —
Bone Meal.
Meat and Bone.

F. E. Hancock, Walkerton, Ont., Can.: —
Canada Unleached Hardwood Ashes.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Animal Brand.
Swift's Lowell Potato Phosphate.
Swift's Lowell Market Garden Manure.
Swift's Lowell Fruit and Vine.
Swift's Lowell Lawn Dressing.
Swift's Lowell Tobacco Manure.
Swift's Lowell Ground Bone.
Swift's Dissolved Bone and Potash.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Success Fertilizer.
Lister's Special Potato Fertilizer.
Lister's Celebrated Onion Fertilizer.
Lister's Special Tobacco Fertilizer.
Lister's High-grade Special for Spring Crops.

Lowe Bros. & Co., Fitchburg, Mass.: —
Tankage.

F. R. Lalor, Dunnville, Ontario, Can.: —
Canada Hardwood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
Mapes Bone Manures.
Mapes Superphosphates.
Mapes Special Crop Manures.
Economical Potato Manure.
Tobacco Ash Constituents.
Sulfate of Potash.
Sulfate of Ammonia.
Nitrate of Soda.
Double Manure Salt.

Geo. L. Munroe, Oswego, N. Y.: —
Pure Canada Unleached Wood Ashes.

McQuade Bros., West Auburn, Mass.: —
Fine-ground Bone.

E. McGarvey & Co., London, Ontario, Can.: —
Unleached Hardwood Ashes.

Niagara Fertilizer Works, Buffalo, N. Y.: —
Niagara Wheat and Corn Producer.
Niagara Potato, Tobacco and Hop Fertilizer.

Pacific Guano Co., Boston, Mass.: —
High-grade General Fertilizer.
Soluble Pacific Guano.
Potato Special.
Nobsque Guano.
Grass and Grain Fertilizer.
Pacific Guano with ten per cent. Potash.
Fish and Potash.
Special Potato Manure.

Packers Union Fertilizer Co., New York, N. Y.: —
Animal Corn Fertilizer.
Potato Manure.
Universal Fertilizer.
Wheat, Oats and Clover.
Gardeners' Complete Manure.

A. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Special Strawberry Brand Fertilizer.
Plymouth Rock Brand.
Special Potato Fertilizer.

Parmenter & Polsey Fertilizer Co. — *Con.*
- P. & P. Potato Fertilizer.
- Star Brand Superphosphate.
- A. A. Brand.
- Ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Superphosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.

Quinnipiac Co., Boston, Mass.: —
- Quinnipiac Onion Manure.
- Quinnipiac Havana Tobacco Fertilizer.
- Quinnipiac Dry Ground Fish.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Fish and Potash.
- Quinnipiac Grass Fertilizer.
- Quinnipiac Corn Manure.
- Quinnipiac Potato Phosphate.
- Quinnipiac Climax Phosphate.
- Quinnipiac Pure Bone Meal.
- Dissolved Bone-black.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.

The Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.
- Hubbard's Potato Phosphate.
- Hubbard's Fertilizer for All Soils and All Crops.
- Hubbard's Fertilizer for Oats and Top-dressing.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Fairchild's Formula for Corn and General Crops.
- Hubbard's Grass and Grain Fertilizer.

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Fish and Potash.
- Essex Potato Fertilizer.
- Essex Corn Fertilizer.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Complete Manure for Potato, Roots and Vegetables.
- Essex Odorless Lawn Dressing.
- Essex Dry Ground Fish.

Read Fertilizer Co., New York, N. Y. (D. H. Foster, general agent): —
- Read's Standard.
- Practical Potato Special.
- Bone, Fish and Potash.
- Vegetable and Vine.

Lucien Sanderson, New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Potato Manure.
- Sanderson's Formula A.
- Sanderson's Blood, Bone and Meat.
- Sanderson's Nitrate of Soda.
- Sanderson's Dissolved Bone-black.
- Sanderson's Sulfate of Potash.
- Sanderson's Muriate of Potash.

Standard Fertilizer Co., Boston, Mass.: —
- Standard Fertilizer.
- Standard Special for Potatoes.
- Standard Guano.
- Standard Complete Manure.

M. L. Shoemaker & Co., Limited, Philadelphia, Pa.: —
- Swift Sure Superphosphate for General Use.

F. C. Sturtevant, Hartford, Conn.: —
- Sturtevant's Granulated Tobacco and Sulphur.

Edward H. Smith, Northborough, Mass.: —
- Smith's Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
- Ground Bone.

The South Sea Guano Co., Boston, Mass.: —
- South Sea Guano.

E. A. Tompkins, Jamaica Plain, Mass.: —
- Ferti Flora.

Henry F. Tucker Co., Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Imperial Bone Superphosphate.
- Tucker's Special Potato Fertilizer.
- Tucker's Bay State Special.

I. S. Whittemore, Wayland, Mass.: —
- Complete Manure.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Bone.

The Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- High-grade Fish and Potash.
- Dry Ground Fish Guano.
- Fish and Potash.

Williams & Clark Fertilizer Co., Boston, Mass.: —
- Ammoniated Bone Superphosphate.
- Prolific Crop Producer.
- Potato Phosphate.
- High-grade Special.
- Royal Bone Phosphate.
- Corn Phosphate.

Williams & Clark Fertilizer Co. — *Con.*
- Potato Manure.
- Grass Manure.
- Fish and Potash.
- Onion Manure.
- Bone Meal.
- Dry Ground Fish.
- Muriate of Potash.
- Sulfate of Potash.
- Nitrate of Soda.
- Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
- Superior Truck Fertilizer.
- Havana Tobacco Fertilizer.
- Potato Manure.
- Corn Fertilizer.
- Fruit Fertilizer.
- Royal Wheat Grower.
- Grass and Oats.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
- Fine-ground Bone.

J. M. Woodard & Brother, Greenfield, Mass.: —
- Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analyses of materials sent on for examination.
2. Notes on wood ashes and condition of the trade.

1. Analyses of Materials sent on for Examination.

During the past season 225 materials have been received, and the results of our examination have been published in detail in bulletins 59, 62 and 63 of the Hatch Experiment Station of the Massachusetts Agricultural College, together with the results of the official inspection of commercial fertilizers.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for analyses, and our publication of results merely refers to the locality they come from. It is evident, from the increase each year of the number of materials sent in for analysis, that there is a growing interest taken in this work, and individuals are realizing the value of such chemical investigations.

The waste products of many industries are of such a nature that their value as manurial substances is unlimited and the current modes of manufacture are constantly undergoing changes which affect seriously their commercial manurial value. A frequent investigation of this class of materials cannot help but prove beneficial to the farmer, and hence arrangements will be made, as in previous years, to attend to the examination of these materials to the full extent of our resources. This work is carried on free of charge to the farmers of this State, the results of analysis being returned in the order of the arrival of samples at the office. Below

is given a partial list of materials received during the past season, which shows the general nature of the work: —

Wood ashes.	Damaged grain.
Sulfate of potash.	Insecticides.
Muriate of potash.	Composts.
Nitrate of soda.	Refuse from glass factory.
Sulfate of ammonia.	Cotton-seed meal.
Acid phosphates.	Cotton-hull ashes.
Sulfate of potash and magnesia.	Tankage.
Ground bone.	Wool shoddy.
Complete fertilizers.	Jadoo fibre.
Minerals.	Plaster.
Liquid fertilizers.	Forage crops.
Soils.	Soot.
Dried pig's blood.	Spent bone-black.
Lime-kiln ashes.	Brick-yard ashes.
Glucose sugar refuse.	Sludge.

These, together with other manurial products common to commercial and agricultural industries, are carefully investigated, and the results of our examination are free to those who may desire such information.

2. Notes on Wood Ashes.

This subject has engaged our attention for past seasons and has been discussed at length in previous reports.

During the past year (1899) 24.4 per cent. of the materials sent on for analysis consisted of wood ashes, as against 40.1 per cent. the previous year (1898).

The wood ashes sold for manurial purposes in our State are subject to official inspection, and the dealers in this commodity must secure a license to sell before they can legally advertise their article. The goods must be sold on a guaranteed analysis, stating their percentages of potash and of phosphoric acid present, and this analysis must be fastened to each package or car that contains them. As the dealer is obliged only to guarantee the amount of potash and of phosphoric acid present in the ashes, no objection can be raised regarding the amount of moisture, so long as the specified amount of those two elements is present. Wood ashes

ought to be bought and sold by weight and *not* by measure, for both moisture and the general character of foreign matters are apt to seriously affect the weight of a given volume.

	No. of Samples.	
	1898.	1899.
Moisture below 1 per cent.,	–	2
Moisture from 1 to 3 per cent.,	9	6
Moisture from 3 to 6 per cent.,	6	4
Moisture from 6 to 10 per cent.,	20	11
Moisture from 10 to 15 per cent.,	22	28
Moisture from 15 to 20 per cent.,	16	7
Moisture from 20 to 30 per cent.,	6	1
Moisture above 30 per cent.,	–	1
Potassium oxide above 8 per cent.,	4	4
Potassium oxide from 7 to 8 per cent.,	6	9
Potassium oxide from 6 to 7 per cent.,	8	13
Potassium oxide from 5 to 6 per cent.,	22	7
Potassium oxide from 4 to 5 per cent.,	25	19
Potassium oxide from 3 to 4 per cent.,	11	2
Potassium oxide below 3 per cent.,	3	2
Phosphoric acid above 2 per cent.,	6	4
Phosphoric acid from 1 to 2 per cent.,	60	43
Phosphoric acid below 1 per cent.,	13	10
Average per cent. of calcium oxide (lime),	33.60	34.10
Per cent. mineral matter insoluble in diluted hydrochloric acid: —		
Below 5,	1	–
5 to 10,	16	16
10 to 15,	31	26
15 to 20,	15	7
20 to 30,	13	5
Above 30,	–	2

Cotton-hull Ashes. — This waste product is receiving increased attention from the farmers, and is an article of great merit. The samples received this year analyze from 21 to 29 per cent. of potash, and are especially adapted to tobacco growing on account of the large proportion of carbonate of potash present, this form of potash being the most valuable one known for that purpose.

Sludge. — At the present time the larger cities are collecting all waste débris in reservoirs, and subjecting it to chemical treatment for recovery of fertilizing ingredients. This source of plant food is often within easy reach of the farmer, and may be turned to good advantage, as is seen

from the average analysis: nitrogen, 1.31 per cent.; potash, .16 per cent.; phosphoric acid, .86 per cent.; lime, 1.13 per cent.

Hen Manure. — In this ingredient we have a very rich fertilizer and a material that is worthy of careful treatment. To save the nitrogen that otherwise might pass into the air a "fixer" is a necessity. Two samples received at the laboratory were analyzed, as follows: —

SAMPLES.	Nitrogen (Per Cent.).	Potash (Per Cent.).	Phosphoric Acid (Per Cent.).
Sample I., ...	.46	1.12	.69
Sample II., ...	.42	.43	.63

No. I. was treated with kainite, a material analyzing on an average 16 per cent. potash, and a substance capable of fixing the ammonia, thereby saving this element and at the same time supplementing the manure in potash, — the ingredient which it is deficient in. This application of an ammonia fixer may be applied to all animal refuse products, and, as is seen, has a twofold action, — the saving of nitrogen and the supplementing of potash.

Cotton-seed Meal. — This material still holds its own and is a recognized standard article, a source of nitrogen sought by tobacco growers. Its high standard has been maintained as in previous seasons.

INDEX.

PUBLIC DOCUMENT . . . . No. 33.

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OF THE

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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Henry T. Fernald, Ph.D.,	*Associate Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
James E. Halligan, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant Chemist* (foods and feeding).
James W. Kellogg, B.Sc.,	*Assistant Chemist* (foods and feeding).
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Henry L. Crane, B.Sc.,	*Assistant Horticulturist.*
Charles L. Rice,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 43. Effects of electricity on germination of seeds.
No. 47. Field experiments with tobacco.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 58. Manurial requirements of crops.
No. 59. Fertilizer analyses.
No. 61. The asparagus rust in Massachusetts.
No. 63. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 66. Variety tests of fruits; fertilizers for fruits; thinning fruits, pruning; spraying calendar.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

Of the numerous problems presented for solution, a few only of the more important have been selected. From a series of experiments on the effect of food on the composition of milk and butter fat and on the consistency or body of butter, it was found: (*a*) that different amounts of protein do not seem to have any influence on the composition of milk; (*b*) that, in general, feeds containing much oil have a tendency to slightly increase the fat content of milk when first fed, but after a few weeks the fat percentage gradually returns to normal; (*c*) that it is not practicable to feed large amounts of oil to cows, as it has a tendency to derange the

digestive and milk-secreting organs; (*d*) that linseed oil effected a noticeable change in the composition of the butter fat, causing a decrease in the volatile acids and an increase in the melting point and iodine coefficient; (*e*) and that cotton-seed meal produced butter fat quite similar in composition to that produced by the standard ration.

In experiments to show the feeding value of barnyard millet, it is shown: (*a*) that the millet has less nutritive value than corn, for the reason that it must be cut when in early blossom to secure it in the most desirable condition for feeding, while the corn can partially mature its grain and still be readily eaten by animals; (*b*) that it is not suitable for hay and is inferior to maize as a silage crop; (*c*) that it furnishes quite a desirable green feed, especially during the month of August, and for this purpose can be most satisfactorily utilized.

A study of the effects of different chemical solutions on germination brought out some interesting facts. The solutions formed from those substances known to exist in seeds and seedlings were of two kinds: ferments, as diastase and pepsin; and amides, as asparagin and leucin. In each experiment one hundred seeds were used, the solution varying in strength from one-tenth per cent. to two per cent. The seeds were soaked in the solution for twelve hours, then rinsed in water and placed in Zurich germinators. With asparagin as the solution on such seeds as vetch, rape, alfalfa, the average percentage of germination for normals was seventy-four and five-tenths per cent.; for the treated was eighty-eight and eight-tenths per cent. and an acceleration of germination in several seeds. With leucin on buckwheat and alfalfa the average of three experiments gave eighty-three per cent. for normal and ninety-two per cent. for treated. With pepsin and diastase there was in like manner a gain of about ten per cent.

Great complaint having been made of the difficulty of growing asters, fifteen thousand were grown under different conditions of fertilizers, varieties, localities, time of planting and methods of handling. A peculiar and obscure disease was made out, not resulting from organisms of any kind,

but very destructive in its effects. There was an abnormal development, due to disturbance of the assimilative functions of the plant.

Remedies for the various diseases of lettuce grown under glass have occupied the attention of the division of plant pathology for several years. The "drop," which is characterized by rotting of the stem and sudden and complete collapse of the whole plant, is the most destructive of these diseases. The amount of loss is very commonly twenty-five per cent. of the entire crop. It has been found that by sterilizing the soil, either wholly or in part, the drop and its kindred disease can be wholly eradicated or suppressed. Experiment shows that five-eighths inch or three-fourths inch surface covering of sterilized sand or earth gave an average reduction of forty-seven per cent. in the amount of drop; one inch of sterilized sand or earth gave an average reduction of eighty-seven per cent.; one inch and a half of sterilized soil, an average of ninety-three per cent.; and two, three and four inches secured entire immunity from the disease.

In the entomological division the structure and life history of various insect pests have been worked out and published, and the remedies to be employed. Among those thus treated are the grass thrips; the thrips of the greenhouse, attacking cucumbers; the fall canker worm; the marguerite fly; and greenhouse aleurodes, doing great damage to tomatoes and cucumbers grown under glass. The San José scale continues its ravages in the State. It has already been found in thirty-seven different towns, and it probably exists in as many more. It attacks the fruit as well as the bark, and specimens of currants, pears and apples have been sent in so completely covered with them as to render their sale impossible.

In the agricultural division the results of experiments continued since 1890 with oats, rye, soy beans, clover and potatoes seem to indicate that the various manures supplying nitrogen rank in the following order: (*a*) nitrate of soda, barnyard manure, sulfate of ammonia and dried blood; (*b*) that in crops of the clover family as nitrogen gathers, the crops not being turned under, but improvement sought from

roots and stubble, there was no appreciable improvement from soy beans, but marked from clover; (*c*) that potatoes, clovers, cabbages and soy beans did much the best on sulfate of potash, while the yield of corn, grasses, oats, barley, vetches and sugar beets has been equally good on the muriate; (*d*) that, if the muriate is used continuously, sooner or later lime must be applied; (*e*) that, with garden crops, both early and late, the sulfate rather than the muriate should be used; (*f*) that none of the natural phosphates appear to be suited to crops belonging to the turnip and cabbage family; (*g*) that, while it is possible to procure profitable crops of most kinds by a liberal use of natural phosphates, the best practice will probably be found to consist in using one of those in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

A detailed account of the operations of the year is herewith submitted.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1900.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,614 58	
for labor,	4,278 90	
for publications,	409 40	
for postage and stationery,	228 53	
for freight and express,	127 48	
for heat, light and water,	254 96	
for chemical supplies,	108 53	
for seeds, plants and sundry supplies,	602 04	
for fertilizers,	1,168 55	
for feeding stuffs,	136 62	
for library,	157 31	
for tools, implements and machinery,	673 63	
for furniture and fixtures,	51 90	
for scientific apparatus,	384 95	
for live stock,	60 30	
for travelling expenses,	22 02	
for contingent expenses,	125 25	
for buildings and repairs,	595 05	
		$15,000 00
Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,600 00	
from farm products,	1,720 86	
from miscellaneous sources,	1,979 82	
		$18,500 68
Cash paid for salaries,	$8,158 11	
for labor,	4,696 81	
for publications,	556 56	
for postage and stationery,	313 85	
for freight and express,	123 64	
Amount carried forward,	$13,848 97	

Amount brought forward,	$13,848 97	
Cash paid for heat, light and water,	582 04	
for chemical supplies,	525 14	
for seeds, plants and sundry supplies,	611 53	
for fertilizers,	162 47	
for feeding stuffs,	995 78	
for library,	96 95	
for tools, implements and machinery,	107 81	
for furniture and fixtures,	50 73	
for scientific apparatus,	546 38	
for live stock,	125 66	
for travelling expenses,	216 62	
for contingent expenses,	94 00	
for buildings and repairs,	536 60	
		$18,500 68

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1900; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,500.68 and the corresponding disbursements $33,500.68. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1900.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 9, 1900.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, F. W. MOSSMAN,* B. K. JONES,† P. H. SMITH, JR., J. W. KELLOGG.

PART I. — LABORATORY WORK.

Outline of Year's Work.

PART II. — FEEDING EXPERIMENTS AND DAIRY STUDIES.

A. Effect of feed on the composition of milk, butter fat, and on the consistency or body of butter.

B. The feeding value of barnyard millet.

C. Dried distillery grains.

D. Digestion experiments with sheep.

E. The composition of purslane.

F. Parsons' "six-dollar" feed.

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* Resigned Nov. 1, 1900.

† Resigned Nov. 1, 1900, to accept position in the Utah Experiment Station.

PART I.

LABORATORY WORK.

EXTENT OF CHEMICAL WORK.

The work of the chemical laboratory connected with this department has materially increased over all previous years. There have been sent in for examination 287 samples of water, 123 of milk, 888 of cream, 20 of pure and process butter, 29 of oleomargarine, 123 of feed stuffs and 10 of vinegar. In connection with experiments by this and other divisions of the station, there have been analyzed 45 samples of milk and cream, 60 of butter and 695 of fodders and feed stuffs.

In addition to the above, 707 samples of commercial concentrated feed stuffs have been collected under the provision of the feed law, and tested, either individually or in composite; and 40 tonics, condimental feeds, etc., have been examined. This makes a total of 3,036 substances analyzed during the year, as against 2,045 last year and 1,875 in the previous year.

CHARACTER OF CHEMICAL WORK.

Water, Milk, Cream, Feed Stuffs, etc., sent for Examination. — More than the usual number of samples have been received during the year. Sanitary examinations of water have been carried on as in previous years, according to the Wanklyn process, to determine its general fitness for domestic purposes and for live stock. In milk analysis, the percentages of total solids and fat are the usual ones

determined. The percentage of fat only is determined in cream, unless the quantity of other ingredients is requested. An estimation of the percentage of protein is usually all that is necessary to determine the genuineness of a feed stuff. In some cases it is wise to determine the percentage of fat; in others, the percentage of ash and fibre.

Full information concerning water, milk and cream, how to take samples, etc., will be found in our report for 1899. Special information will be furnished upon application.

Cattle Feed Inspection. — We have continued the inspection of concentrated feeds during the year, collecting and analyzing over 700 samples. A bulletin is about to be issued, giving the results of the work accomplished. The better class of feeds is practically free from adulteration. Some manufacturers and jobbers are still disposed to put cotton-seed meal mixed with ground hulls upon the market, marked simply cotton-seed meal. Mixed feed, so called, consisting principally of wheat bran together with several hundred pounds of fine or flour middlings to the ton, is beginning to be adulterated with wheat hulls, ground corn cobs, etc. This material ought to be accompanied by a guaranty to assure the purchaser of its purity. Many very inferior oat feeds, containing 50 to 60 per cent. of oat hulls, are still on sale. They are very expensive at the price asked for them. These inferior oat feeds are often used by millers to mix with cracked corn, the resulting product being sold as provender. It is quite inferior to a mixture of genuine ground oats and corn. New feeds are constantly coming into the market, most of them by-products from different industries. The writer is convinced that the time is nearly at hand for a change in the present feed law, making it conform to the laws in the other New England States.

Methods of Analysis. — This department has co-operated with the Association of Official Agricultural Chemists in investigating different methods of analysis, with a view to their improvement. During the present year investigations have been made relative to the best methods of determining starch, pentosans and galactan in feed materials, and of casein and albumin in milk. Work of this character cannot

be expressed in figures. It consumes much time, but is very necessary, and likely to be productive of valuable results.

Chemical and Physiological Investigations. — So far as time and resources permit, the chemical staff is engaged in investigating some of the many pressing dairy and feeding problems. The time at present is largely devoted to the examination of butter fat, the manufacture of butter and to the digestibility of feeding stuffs. It is to be regretted that the analysis of the various materials sent to the station — waters, milk, cream, butter and feed stuffs — consumes each year an increasing amount of time, and necessarily limits the extent of experimental work.

PART II.

FEEDING EXPERIMENTS AND DAIRY STUDIES.

A.—EFFECT OF FEED ON THE COMPOSITION OF MILK, BUTTER FAT, AND ON THE CONSISTENCY OR BODY OF BUTTER.

J. B. LINDSEY.*

CONCLUSIONS.

As a result of the experiments which follow, concerning the influence of feeds and feed constituents on the composition of milk, butter fat, and on the character of the butter, the following deductions are made: —

1. Different amounts of protein do not seem to have any influence on the composition of the milk.

2. Linseed oil in flax-seed meal, when fed in considerable quantities (1.40 pounds digestible oil daily), increased the fat percentage and decreased the nitrogenous matter of the milk. This fat increase was only temporary, the milk gradually returning (in four or five weeks) to its normal fat content. The nitrogenous matter also gradually returned to normal, but more slowly than the fat.

3. In general, feeds containing much oil have a tendency to slightly increase the fat content of milk when first fed. The fat percentage gradually returns to normal.

4. It is not practicable to feed large amounts of oil to cows, as it has a tendency to derange the digestive and milk-secreting organs.

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* Ably assisted by E. B. Holland, F. W. Mossman, B. K. Jones and P. H. Smith, Jr.

5. Linseed oil effected a noticeable change in the composition of the butter fat, causing a decrease in the volatile acids and an increase in the melting point and iodine coefficient.

6. All oils do not produce the same effects on butter fat.

7. The melting point of butter fat is not always indicative of the firmness or body of butter.

8. An excess of linseed oil produced a soft, salvy butter, with an inferior flavor.

9. Linseed and corn gluten meals, with a minimum percentage of oil (3 per cent.), produced a normal butter fat. The corn gluten meal produced butter with a desirable flavor and of good body.

10. King gluten meal (corn gluten meal with 13 per cent. oil) increased the iodine coefficient of the butter fat several degrees above standard ration butter fat, and slightly depressed the melting point of the fat. This effect was probably due to the corn oil. The same meal produced butter of a very desirable flavor and body.*

11. Cotton-seed meal produced butter fat quite similar in composition to that produced by the standard ration. The butter produced by this meal was rather crumbly when hard, and slightly salvy to the taste.

Further experiments concerning the effects of food and food constituents on butter fat and butter are now in progress.

(*a*) Preliminary Statement.

During the last six years a number of experiments have been made at this station relative to the effect of food, first on the composition of milk and later on the composition of butter fat. It is not the writer's intention at this time to attempt any historical or critical review of the work of others along these lines, nor to present the full data of his own work, but rather to call attention to the progress thus far made in the effort to secure positive knowledge on the subject under investigation. The detailed experiments will be published at a proper time. The writer believes that experimenters have hitherto neglected to note the effect of the several food

* The body of this butter was very satisfactory to Mr. W. A. Gude, the scorer, but might have been considered by some as lacking in firmness.

constituents — protein, fat and carbohydrates — on the milk and butter fat, but have rather attempted to observe the influence of the combinations of these groups as they exist in the different foods. It is believed that the former method would yield more definite information on this perplexing subject.

(*b*) The Effect of Protein on the Composition of Milk.

In an early experiment * different amounts of protein were fed, and the effect on the composition of the milk was noted. The experiment showed that the fat content of the milk appeared to be increased. Unfortunately, the ration contained, in addition to the protein, an excess of corn and cotton-seed oil, derived from gluten feed and cotton-seed meal, and it was not at all clear whether the protein or the oil was responsible for the fat increase. Again, the periods were of too short duration to make clear whether the increase was temporary or permanent. In the next two experiments† the oil factor was eliminated as far as possible, the protein being derived from corn and gluten meals. The length of the periods were increased so as to cover from four to six weeks, and, because of increased facilities for carrying out the experiments, many outside influences bearing upon the results were eliminated. The results of these two investigations showed no particular influence of the protein upon the several ingredients of the milk, except a very slight increase in the nitrogenous matter of the milk when the largest amount of protein was fed. It therefore seemed probable that the oil in the rations fed in the first experiment above referred to was responsible for the fat increase.

(*c*) The Effect of Fat on the Composition of Milk.

About this time (1898), Soxhlet, a German investigator, made the statement that, contrary to general teachings, the fat of the food — as found in the different oil cakes fed on the continent — did produce a very noticeable increase in the

* Report of Massachusetts State Experiment Station, 1894.
† Ninth and eleventh reports of Hatch Experiment Station.

relative amount of fat in the milk. The full data proving this statement has not been published. The conclusion of several American experimenters who had previously fed different fats to dairy animals was that no positive increase was to be observed. Soxhlet suggested that the reason the effect of "food fat" had not been more pronounced was because the fat or oil fed had not been digested and assimilated by the animals. Following out the suggestion made by our first experiment, and endeavoring to prove or disprove Soxhlet's statements, several experiments were instituted.

The first two were made with three animals, — the only ones in condition at the time, — in the summer of 1898, and have been designated Experiments I. and II. It was merely a preliminary test. These animals were in rather an advanced stage of lactation, but producing 15 to 20 pounds of milk each per day. The coarse feeds during the several periods consisted of first and second cut hay, or second cut hay and green feed. The grain feed during the "normal oil" periods was wheat bran, or bran and Chicago gluten meal; and in the so-called "excess oil" periods flaxseed meal* was added to the wheat bran, or was substituted for the Chicago gluten meal. In the normal oil periods the amount of oil calculated to be digested was from .4 to .5 pounds, and during the excess oil periods from 1.4 to 1.8 pounds. The normal oil periods lasted seven days, then followed excess oil period of ten days, subsequently normal oil periods of four days. Each period proper was preceded by a preliminary period of seven days. When the excess oil was fed, the fat of the milk increased one-half per cent. in almost every case (that is, from 5 to 5.50, for example), and in some cases even more, and dropped back again when the excess oil was removed to even below what it was in the first or normal oil period. Part of the increase might be attributed to change of feed. The periods were short and the weather warm, and the experiment could be considered of only sufficient importance to warrant still further investigations under more favorable conditions.

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* This meal contained about 37 per cent. of linseed oil.

Experiment III.

[New-process linseed meal (Cleveland flax meal) *v.* flaxseed meal.]

The next experiment was begun in October, 1898, and continued until February, 1899. The cows, ten in number, were divided as evenly as possible into Herds I. and II. Both herds received rowen (second cut hay) as the coarse fodder during the entire experiment. The grain ration for each herd consisted of bran, new-process linseed meal* (Cleveland flax meal, so called) and corn meal during the first period of three weeks, one week of which was preliminary. This was designated the "normal oil" ration. In the second period of twelve weeks Herd II. received flaxseed meal in place of the Cleveland flax meal, and corn meal; and the entire ration of Herd I. was continued unchanged. The ration consumed by Herd II. in the second period was designated the "excess oil" ration. The third period proper lasted two weeks, and both herds were fed the same ration as in the first period. Herd I. then received the same (normal oil) ration throughout the entire experiment and Herd II. the excess oil ration in the second period. The normal oil ration consisted of about .5 pounds of digestible oil and the excess oil ration of 1.75 pounds. The amount of protein and carbohydrates were essentially the same, the oil being the varying factor.

Daily Ration (Pounds).

First period: both herds normal oil ration.

HERDS.	Wheat Bran.	Cleveland Flax Meal.	Flaxseed Meal.	Corn Meal.	Rowen.
Herd I.,	2	2	-	2 to 3	20 to 24
Herd II.,	2	2	-	2 to 3	20 to 24
Second period: Herd I., normal oil ration; Herd II., excess oil ration.					
Herd I.,	2	2	-	2 to 3	20 to 24
Herd II.,	2	-	4	0 to 1	20 to 24
Third period: both herds normal oil ration.					
Herd I.,	2	2	-	2 to 3	20 to 24
Herd II.,	2	2	-	2 to 3	20 to 24

* This meal contained less than 3 per cent. of oil.

The animals completed the experiment with only slight disturbances. Composite samples of each cow's milk and of the mixed milk of each herd were made for five days of each week, and the milk was tested for total solids, fat, nitrogen and ash. The analyses of the mixed milk only are presented at this time: —

Milk Analyses.

First period: both herds normal oil ration.

SAMPLES.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.		Ash.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Weekly sample,	13.27	13.25	4.23	4.05	9.04	9.20	0.519	0.531	0.69	0.72
Weekly sample,	13.55	13.43	4.62	4.40	8.93	9.03	0.539	0.543	0.70	0.71
Weekly sample,	13.79	13.62	4.59	4.52	9.20	9.10	0.547	0.544	0.72	0.72
Averages, .	13.54	13.43	4.48	4.32	9.06	9.11	0.535	0.539	0.70	0.72

Second period: Herd I., normal oil ration; Herd II., excess oil ration.

Weekly sample,	14.00	14.36	5.07	5.56	8.93	8.80	0.550	0.511	0.71	0.72
Weekly sample,	14.12	-	5.05	-	9.07	-	0.581	-	0.71	-
Weekly sample,	14.16	14.25	4.96	5.24	9.20	9.01	0.572	0.529	0.72	0.71
Weekly sample,	14.21	14.19	5.16	5.27	9.05	8.92	0.574	0.532	0.73	0.71
Weekly sample,	14.26	14.02	5.08	5.14	9.18	8.88	-	-	-	-
Weekly sample,	14.21	14.03	5.13	5.19	9.08	8.84	0.575	0.519	0.72	0.71
Weekly sample,	14.07	13.85	4.85	4.96	9.22	8.89	0.575	0.517	0.72	0.70
Weekly sample,	14.07	13.92	4.85	5.00	9.22	8.92	0.572	0.531	0.72	-
Weekly sample,	-	13.96	-	5.05	-	8.91	-	-	-	-
Weekly sample,	14.30	14.06	4.85	4.93	9.45	9.13	0.587	0.536	0.72	0.71
Averages, .	14.16	14.07	5.00	5.15	9.16	8.92	0.573	0.525	0.72	0.71

Third period: both herds normal oil ration.

Weekly sample,	14.14	13.54	4.87	4.38	9.27	9.16	-	0.561	-	0.70
Weekly sample,	14.06	13.70	4.68	4.28	9.38	9.42	-	0.566	-	0.71
Averages, .	14.10	13.62	4.77	4.33	9.33	9.29	-	0.563	-	0.71

In studying the *average results*, one notes that in the first period both herds produced milk of approximately the same quality. The second period of twelve weeks showed an increase in the fat of Herd I. from 4.48 to 5, or .52 per cent.,

— a natural increase, due to the advance in the period of lactation; and in Herd II. from 4.32 to 5.15, or .83 per cent. The percentage increase in Herd I. was 11.6 per cent. and in Herd II. 19.2, showing that Herd II. made the greater average increase. The total solids increased about the same in each herd. The average nitrogen percentage increased for Herd I. from .535 to .573, in about the same proportion as the total solids; while Herd II., instead of showing an increase, had a slight decrease. The ash remained practically unchanged. In the third period there was a slight decrease in the total solids and fat of Herd I., and a very noticeable decrease in the fat of Herd II. The nitrogen percentage of Herd II. in this period increases to about the average produced by Herd I. in the second period. To note, however, the full effect of the excess oil ration, one must observe the weekly analyses of the milk of both herds in the excess oil period. For example, the last fat test in the normal oil period was 4.59 per cent. for Herd I. and 4.52 per cent. for Herd II. The first fat test in the second period was 5.07 for Herd I. (receiving the normal oil ration) and 5.56 for Herd II. (receiving the excess oil ration). During this entire period Herd I. showed little variation in fat, and averaged 5 per cent. Herd II. increased from 4.48 to 5.56 at the beginning of the excess oil period, and then gradually decreased, until at the close of the period it tested 4.93 and averaged 5.15 per cent. of fat. When it is remembered that the figures given represent the mixed milk of five cows, it seems safe to conclude that the excess of oil did increase the percentage of fat in the milk, but the increase was only temporary, the fat percentage gradually dropping back to an amount parallel with Herd I. The nitrogen percentage of Herd II. in the second period did not increase so rapidly as did the fat. At the beginning of the period it was less than at the close of Period I., and did not begin to increase until near the close of the period. In the third period it was apparently normal again.

One might suppose that the fat increase in the case of Herd II. could be accounted for by the shrinkage in milk production. The shrinkage, however, was no more than

with Herd I. Again, should this be the case, why should not the nitrogen increase in the same proportion, instead of actually decreasing, etc.?

To summarize briefly, the marked effect of the oil was to produce a quite noticeable increase in the percentage of milk fat when first fed; this increase gradually diminished, until at the end of the fifth week it reached the normal.* When the excess oil ration was removed, the milk fat percentage dropped noticeably below the normal. A second effect of the oil ration was to cause a depression in the percentage of nitrogen in the milk, which began to increase only towards the close of the period, and increased to the normal percentage when the excess oil ceased to be fed. As a result of this experiment, one is led to inquire in what way the oil in the feed caused the temporary increase of fat in the milk. Does the *feed oil* to any extent enter directly into the milk fat, or does it by substitution cause the body fat to be utilized by the animal in the production of milk fat, as Soxhlet suggests; or does the feed oil produce a disturbance in the milk glands, causing an increased fat secretion, by utilizing a portion of the material that would otherwise become nitrogenous matter and milk sugar? These are questions worthy of further investigation.

This experiment is rather more decisive in its teachings than many earlier investigations. The question for further investigation is, whether other oils, derived from cotton-seed, corn, etc., act in a similar way to linseed oil. Investigations touching this and other points are now in progress.†

(*d*) The Effect of Linseed Oil on Butter Fat.

Two samples of butter fat were taken weekly from each herd, in the experiment above described, and upon analyses yielded the following *average* results: —

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* By normal is meant the percentage produced by Herd I.

† This experiment was completed during the winter of 1898–99, but has remained unpublished, owing to the prolonged illness of the writer. Since that time Hills (twelfth report, Vermont Experiment Station), Rhodin (Milch Zeitung 27, pp. [illegible]-323, 1898), Bartlett (fourteenth report, Maine Experiment Station) and others have published results of a similar nature, to which more extended reference will be made at another time.

Butter Fat Analyses.

First period: both herds normal oil ration.

HERDS.	Length of Period (Weeks).	Specific Gravity $\left(\frac{100}{100}\right)$.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Melting Point (Degrees C.).	Iodine Number.
Herd I., . . .	2	.905	29.79	5.24	31.99	28.93
Herd II., . . .	2	.906	28.62	5.04	32.24	30.02
Second period: Herd II., excess oil ration.						
Herd I., . . .	12	.904	30.28	5.33	32.89	28.16
Herd II., . . .	12	.903	25.17	4.43	36.93	43.19
Third period: both herds normal oil ration.						
Herd I., . . .	2	-	-	-	-	-
Herd II., . . .	2	-	27.96	4.92	33.03	32.15

The averages show that the effect of the oil was to depress the volatile acids and to increase the melting point and iodine number. The change was noted in the case of Herd II. at the beginning of the excess oil period, and continued uninterrupted until its close.

In the third period of two weeks (one week preliminary and two weeks proper), in which both herds received the normal oil ration, the butter fat in case of Herd II. changed in composition nearly to that of Herd I. at the close of the second period. The effect of the change of feed was observed at the close of the first week, but it seemed to require several weeks for the animals to thoroughly readjust themselves. It is evident that the linseed oil caused a butter fat to be produced having lower volatile acids than that produced in the normal oil period. One would also assume that it caused a change in the relative proportions of stearin, palmitin and olein. The question arose as to whether linolic and linolinic acids — the characteristic acids of linseed oil — had been actually transmitted to the butter fat, and an effort was made to detect them, but without positive results. We hope to still further investigate this matter.

(e) The Effect of Linseed Oil on Butter.

When this experiment was begun it was not the intention to convert the cream into butter, but to note particularly the effect of the oil on the composition of the milk and butter fat. The oil, however, effected such a change in the chemical character of the butter fat that it seemed wise to note its effect on the resulting butter product. Accordingly six lots of butter were made from each herd, towards the close of the second or excess oil period. It was not possible at the time to make a first-class article, owing to poor facilities. We were obliged to ripen the cream in cans, to churn with a small hand churn and to work the butter with a small paddle.* Two lots of butter from each herd were submitted to chemical analysis, and found to be of normal character. They contained from about 10 to 12 per cent. of water, 85 to 87 per cent. of butter fat, less than 1 per cent. of curd and a normal amount of salt. The several samples were scored by Mr. W. A. Gude, of the firm of Gude Bros., New York, who stated that both lots were of poor flavor, having a burnt taste, as of rendered butter; and the body from Herd I. was short grained, brittle and crumbly; from Herd II., salvy or very salvy.

Mr. C. H. Eckles, butter maker at the college dairy school, reported as follows concerning the body and flavor of the several butters: "The butter from the normal ration is considerably firmer than that from the excess oil ration, and the grain is shorter. As compared with the product of the best creamery butter, neither is exactly normal in consistency, the normal ration butter being more crumbly and the butter from the excess oil ration more salvy or greasy than normal. From a commercial stand-point, the body of excess oil butter is possibly the more objectionable. The flavor and aroma of normal ration butter is inferior to that of excess oil butter. In case of the former, something of an old flavor, impossible to describe, is noticed. The flavor of excess oil butter, while not very good, is more the flavor

* Since then a small dairy building for experimental purposes has been erected and fully equipped for this department.

of fresh butter." Referring to another lot, Mr. Eckles says: "The same difference in consistency was observed, and in about the same degree, and the difference in flavor was the same, but more marked."

The writer lays no claim to being an expert judge of butter, but his observations, made at the time, were as follows: Butters from normal ration were hard and firm at 15° C., and those from excess oil ration of a softer, lardy nature. It required some effort to force a glass rod into normal ration butter, but the same rod slipped much easier into excess oil butter. One could distinguish the two butters almost with the eye, and easily with the touch. Samples of the two butters were placed in crystallization dishes upon a hot-water radiator. Normal ration butter remained firmer for a time than excess oil butter, but resolved itself into oil more quickly. When normal ration butter was nearly all oil, excess oil butter was soft enough to spread out over the bottom of the dish, but had melted but little. This latter observation is very interesting, and shows, at least in case of this experiment, *that the melting point of the butter fat did not govern the firmness or body of the butter*. Does this hold true in all cases? The average melting point of normal oil butter fat was 32.89 and of excess oil butter fat 36.93. While the excess oil butter fat showed a melting point 4° higher than the normal oil fat, yet the normal oil butter was firmer at ordinary temperature, and kept its body better when a gentle heat was applied. When, however, the heat was increased, the firmer normal oil butter actually resolved itself into oil more quickly than did the salvy excess oil butter. The reason for this cannot be discussed at this time.

It is clear, from the foregoing observations, that the butters from both herds were of quite inferior flavor. It was unfortunate that our facilities for butter making at the time were not better. Just why the flavor of both lots was so poor is not quite clear, as they were made by an experienced butter maker, the stable was clean and the milk carefully handled. How much of this is to be attributed to poor facilities, how much to inferior bacteria and how much to influence of food, cannot be ascertained. The butters were

probably rather overworked. One point, however, stands out *very distinctly; namely, the influence of food on the body of the butter.* The linseed oil surely produced a butter of high melting point, yet soft and salvy, and unable to stand up under a gradually rising temperature, as did the butter when the oil was not fed.

The above experiment naturally suggests two questions: First, do the oils in the various feed stuffs tend to produce a salvy butter, lacking in firmness? Second, what is the effect of different forms of protein, as found in linseed, cotton-seed and gluten meals on the body of butter?

(*f*) The Effect of Different Concentrated Feeds on Butter Fat and Butter.

At the close of the above experiment it seemed advisable to note the effect of several concentrated feeds, as they are found in the markets, upon the character of butter fat and butter. Accordingly a "standard" grain ration was adopted, and other rations compared with it. It is not to be inferred that the so-called "standard" ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce a normal butter.

Two experiments, known as Experiments IV. and V.,* were completed in the spring of 1898, with twelve cows, divided into two herds of six cows each. Rations containing 4 pounds of Cleveland flax meal and 4 pounds of Chicago gluten meal, respectively, were compared with the standard ration. Herd II. received the standard ration, and Herd I. the Cleveland flax meal and Chicago gluten meal rations. All these rations contained only a normal amount (.5 to .6 pounds) of digestible oil, while the Cleveland flax or the Chicago gluten meal themselves contained less than 3 per cent. of oil, so that one could note particularly the effect of the protein in the linseed and gluten meals on the butter fat and butter.

* These two experiments were made in connection with the Department of Agriculture.

Daily Ration (Pounds).

RATIONS.	Wheat Bran.	Ground Oats.	Cotton-seed Meal.	Chicago Gluten Meal.	Cleveland Flax Meal.	First Cut Hay.	Corn Silage.
Standard ration,	3	5	.5	.5	–	12–15	20
Cleveland flax meal ration.	2	2	–	–	4	12 15	20
Chicago gluten meal ration.	2	2	–	4	–	12–15	20

The experiments proper lasted five weeks, preceded by a preliminary period of ten to fourteen days.

Experiment IV.

[Standard ration *v.* Cleveland flax meal ration.]

Five samples of butter fat were analyzed, with the following average results : —

Butter Fat Analyses.

RATIONS.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Insoluble Acids.	Melting Point.	Iodine Number.
Standard ration,.	30.92	5.44	88.48	33.80	28.96
Cleveland flax meal ration,	29.50	5.19	88.69	33.23	26.77

The averages show comparatively slight variations, the fats resulting from both rations being normal in character. The Cleveland flax meal ration produced a fat with less volatile acids and a trifle lower melting point and iodine number than did the standard ration. Whether this difference is due to the individuality of the two herds, or to the influence of the linseed meal, cannot be stated.

Ten lots of butter were made from each herd. The ripening, churning, etc., were made in the same way as in the previously described linseed oil experiment (Experiment III.). Five lots of butter made from each ration were analyzed and found to be of normal character. The ten lots were scored by Mr. W. A. Gude of New York, with the following average results : —

Average Butter Score.

	Flavor.	Body.	Color.	Salt.	Style.	Total.
Standard ration, ...	35.9	24.2	15	10	5	90.1
Cleveland flax meal ration, . . .	31.4	22.0	15	10	5	82.4
Standard score, ...	45.0	25.0	15	10	5	100.0

Mr. Gude reported the flavor of the butter from the flax meal ration as "stale, rancid or oily," "strong, oily, seems rancid," "oily," etc. Concerning the flavor of standard ration butter he reported "fair to fine" and in four instances he referred to "oily flavor." With regard to body of flax meal butter he used the terms "brittle, dry, salvy, short," and for standard ration butter "good, but trifle short," and "perfect." In a letter Mr. Gude said: "While trying to pay particular attention to body, I notice that the most objectionable feature is that peculiar oily taste," etc. "This I notice you have apparently overcome in No. 1282" (standard ration butter). Again: "I notice a particular improvement in the quality, particularly of samples 1272 and 1274" (standard ration butter).

The butters were rather dry, having about 12 per cent. of water. It is clear that, while the butter made from both rations did not score high, that made from the flax meal ration was noticeably inferior in flavor and in body to the standard ration butter. This seems to agree with the linseed oil experiment (Experiment III.). In that experiment, even when only two pounds of flax meal were fed, the flavor was inferior; and when flax-seed meal was fed the body and flavor were both bad. It is not desired, however, to be too positive about the flax meal (linseed meal, with a minimum amount of oil) producing an inferior-flavored butter, but we prefer to call attention to the results thus far secured, and to repeat the experiment.

Experiment V.

[Standard ration *v.* Chicago gluten meal ration.]

This experiment was identical with Experiment IV., excepting that 4 pounds of the Chicago gluten meal (corn gluten) were substituted for 4 pounds of flax meal. The average results of the analyses of five samples of butter fat follow: —

Butter Fat Analyses.

RATIONS.	Reichert-Meissl Number.	Butyric Acids Equivalent.	Insoluble Acids.	Melting Point.	Iodine Number.
Standard ration,	30.07	5.29	88.84	34.76	29.00
Chicago gluten meal ration,	32.07	5.64	88.26	33.04	27.67

No wide variations are noted. The Chicago gluten ration produced rather more volatile acids, a trifle less insoluble acids, a lower melting point and a lower iodine number. The differences are too slight to draw any positive conclusions. In both these experiments (Experiments IV. and V.) one notes that the standard ration produced butter with a little higher melting point and a lower iodine number. All the butter fats, however, were of normal character.

Ten lots of butter were made from each ration, under similar conditions, as previously described. Five samples were analyzed chemically and found to be normal. The butter was quite dry, showing but 11 per cent. of water. Mr. Gude scored the ten samples made from each ration with the following average results: —

Average Butter Score.

	Flavor.	Body.	Color.	Salt.	Style.	Total.
Standard ration,	35.6	23.8	15	10	5	89.4
Chicago gluten ration,	35.2	24.0	15	10	5	89.2
Standard score,	45.0	25.0	15	10	5	100.0

These butters appear to be practically identical, no particular feed influence being noted. The first four or five lots

from each ration were reported as having a "tainted off flavor," and were marked down. The last five lots were reported as being "good," "clean flavor," etc., and scored 38 and 39 out of a possible 45. The body of each of the two lots was reported a "trifle short," "brittle," "breaks easily," etc., and were marked down one point. The score is not very high, due to rather poor flavor. This is attributed, partly at least, to rather poor facilities in ripening and handling and not to feed. The corn gluten in this case does not appear to have had any bad influence on the body of the butter. It is held by many that gluten products produce a soft, salvy butter. This we are inclined to attribute to the influence of the corn oil, which is now largely removed before the gluten products are put upon the market. Bartlett's recent experiments support this view.*

Both lots of butter were tested for firmness of body by the usual method of allowing a plunge of given weight to drop from a certain height, noting the degree of penetration in millimeters. The average figures were 6.9 millimeters for the standard ration, and 6.7 millimeters for the Chicago gluten meal ration, showing practically no difference.

Experiment VI. 1899–1900.

[Period I., standard ration, both herds; Period II., standard ration *v.* King gluten meal ration; Period III., standard ration *v.* cotton-seed meal ration.]

During the winter of 1899–1900 another experiment was instituted, to note the effect of King gluten meal, with 14 per cent. corn oil, and normal cotton-seed meal, with 12.6 per cent. oil, on the butter fat and butter. Ten cows were divided as evenly as possible into herds of five each. In the first period, lasting two weeks,† both herds were fed the standard ration. In the second period of five weeks † Herd I. received the standard ration and Herd II. the King gluten meal ration. In the third period of five weeks † Herd I. received the standard ration and Herd II. the cotton-seed meal ration. It will thus be seen that both Herds received the same ration in the first period, then Herd II. was changed

* Maine Experiment Station report, 1898, pp. 97–113.

† Preliminary period of two weeks not included.

to the other two rations and Herd I. was used as a check for comparison. The several rations were as follows: —

Daily Rations (Pounds).

RATIONS.	Wheat Bran.	Ground Oats.	Cotton-seed Meal	Chicago Gluten Meal.	King Gluten Meal.	Corn Silage.	Hay.
Standard ration, . . .	3	5	.5	.5	-	20	10–15
King gluten meal, . . .	2	2	-	-	4	20	10–15
Cotton-seed meal, . . .	2	2	4	-	-	20	10–15

The average results follow: —

Analyses of Butter Fat.

First period: both herds standard ration.

HERDS.	Number Samples.	Saponification Equivalent.	Insoluble Acids.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Melting Point (Degrees C.).	Iodine Number.
Herd I., .	4	233.3	88.35	32.18	5.67	34.08	25.84
Herd II.,	4	232.9	87.98	32.64	5.74	33.94	26.78

Second period: Herd I., standard ration; Herd II., King gluten meal ration.

Herd I., .	10	232.4	88.27	31.48	5.54	34.00	26.44
Herd II.,	10	231.0	88.24	32.62	5.76	32.80	32.75

Third period: Herd I., standard ration; Herd II., cotton-seed meal ration.

Herd I., .	10	229.6	88.62	30.56	5.38	34.12	26.35
Herd II.,	10	227.9	88.70	31.03	5.46	35.60	29.35

The experiment began December 7 and ended April 15, or 130 days. It is interesting to note the evenness in the composition of the butter fat during this time produced by Herd I. receiving the standard ration. There was a slight decrease in the saponification equivalent and the Reichert-Meissl number, but practically no change in the melting point or iodine number.

In the first period both herds produced butter fat of similar composition. In the second period the fat produced by Herd II., receiving the King gluten meal ration, showed no

change in Reichert-Meissl number, a slight depression in melting point and a noticeable increase in the iodine number. The effect would probably have been more marked had more corn oil been fed. In the case of the linseed oil experiment both the melting point and iodine number were increased.

In the third period the fat produced by the cotton-seed meal ration showed but little change in composition from that produced by the standard ration.

It seems evident that different oils — linseed, corn and cotton-seed oils — exert a different influence on butter fat, these oils themselves being of different composition.

In making the butter, the creams, raised by the gravity process, were treated as nearly alike as possible. Our dairy building was completed, and afforded excellent facilities for doing the work. The cream was ripened to approximately .7 acidity in forty-eight hours. A skim-milk starter was used without the aid of any specially prepared ferment. Every sample of butter was analyzed and found to be normal, showing about 12 per cent. of water, 80 to 82 per cent. of butter fat and 1 per cent. casein. The butters were scored by Mr. W. A. Gude, with the following average results: —

Average Butter Score.

First period: both herds standard ration.

HERDS.	Number Samples.	Flavor.	Body.	Color.	Salt.	Style.	Total.
Herd I.,	4	36.2	23.4	15	10	5	89.6
Herd II.,	4	36.2	23.4	15	10	5	89.6

Second period: Herd I., standard ration; Herd II., King gluten meal ration.

Herd I.,	10	37.8	24.0	15	10	5	91.8
Herd II.,	10	39.7	24.9	15	10	5	94.6

Third period: Herd I., standard ration; Herd II., cotton-seed meal ration.

Herd I.,	10	36.0	24.1	15	10	5	90.1
Herd II.,	10	35.9	24.4	15	10	5	90.3
Standard score,	–	45.0	25.0	15	10	5	100.0

Mr. Gude's notes concerning the different samples are as follows: First period: flavor, "fair aroma," "fairly clean," "oily taste;" body, "short and breaks easily, seems brittle," "slightly short and brittle." Second period: flavor, Herd I., "fairly clean, lacks aroma," "defective;" Herd II., "clean and fine;" body, Herd I., "brittle, short, seems light and spongy, trifle salvy;" Herd II., "all right." Third period: flavor, Herd I., "fairly clean, but lacks aroma," "slight taints;" body, Herd I., "spongy when soft, short and crumbles when hard;" Herd II., "perfect," "short when soft, crumbles when hard," "salvy to taste."

Average Degree of Penetration (Millimeters).

HERDS.	First Period.	Second Period.	Third Period.
Herd I.,	4.8	4.9	5.4
Herd II.,	4.9	6.7	5.8

Our own deductions, based on the score and remarks of Mr. Gude and the degree of penetration concerning this experiment, are as follows: The tendency of the standard ration was to make butter with a firm body and likely to crumble. It seemed also to produce at times a slight oily or defective flavor. The hardness is probably due to the oats, and possibly the oily flavor to the oil of the oats. The King gluten meal seemed to produce a butter very satisfactory to Mr. Gude. He gave it an average score of 94.6, spoke of its flavor as clean and fine and of its body as perfect. The degree of penetration shows it to be a softer, more yielding butter than that produced by the standard ration. This condition is probably brought about by the corn oil. Butters of this consistency are objected to by some. It is our intention soon to feed corn gluten without oil, and the same with different quantities of oil.

The cotton-seed ration produced butter of about the same quality and condition as the standard ration. Mr. Gude spoke of it as lacking aroma and having a slight taint, and of being rather spongy when soft and crumbling when hard. This butter is firmer than the King gluten butter. It would

be of interest to note the influence of the cotton-seed protein and the cotton-seed oil separately on the butter, and we hope to carry out such experiments.

It is clear, from our several experiments, that food does influence to a noticeable degree the composition of the butter fat and the body of the butter. It seems also to influence the flavor; to what extent, as compared with the influence produced by bacteria, is not quite clear. This matter is being given further study.

B. — THE COMPOSITION, DIGESTIBILITY AND FEEDING VALUE OF BARNYARD MILLET (*Panicum crus-galli*).

J. B. LINDSEY.

Conclusions.

1. Barnyard millet is a warm-weather plant, similar in this respect to Indian corn.

2. As harvested in early blossom, the fodder contains less nitrogen-free extract matter, more fibre or woody matter, and rather more ash than corn fodder. The seed resembles the cereals (especially oats) in composition. It contains considerable more fibre, rather more ash and 5 to 6 per cent. less extract matter than maize.

3. Barnyard millet, grown on naturally moist and fertile land, will probably yield as much dry matter per acre as corn.

4. It has less nutritive value than the corn, the principal reason for this being that the corn can partially mature its grain and still be readily eaten by animals, while the millet must be cut when in blossom to secure it in the most desirable condition for feeding.

5. It is not suitable for hay, and, while it makes a fairly satisfactory silage, it is inferior to maize as a silage crop.

6. It furnishes a desirable green feed, especially during the month of August, and *it is for this purpose that it can be most satisfactorily utilized*.

7. The millet can be used for silage in place of corn whenever it is not convenient or possible to grow the latter.

Preliminary Statement.

During the last ten years the attention of farmers has been frequently called to the value of several varieties of Japanese millets.* Experiments have demonstrated the *Panicum crus-galli* — now termed barnyard millet — to be the most useful Japanese variety for fodder purposes; and this department has endeavored to ascertain, by experiment and observation, its relative value, as compared with other materials of similar character, as a food for dairy animals. The term barnyard millet has been adopted as its common name, for the reason that it appears to be a cultivated and improved variety of the common barnyard grass. The information given below is not meant to be an exhaustive treatise on the subject, but rather a bringing together of data already at hand concerning the nutritive value and practical utility of the plant.

(*a*) Character of the Millet.

This variety of millet is a coarse-growing form, with a comparatively heavy leafage and compact beardless heads. When headed out it stands from four to six feet in height, and rarely lodges. It is a warm-weather plant, similar to corn, and makes a very rapid growth when the temperature is high. Sown the middle of May, it begins to head about August 1, the time varying a little, depending on weather conditions. After the heads appear it becomes woody, and proportionately less valuable for fodder purposes. It will not endure dry weather as well as corn, and succeeds best upon moist land in a good state of fertility. If cut when it begins to bloom, a second crop may be frequently secured, but it is apt to be small in quantity and coarse in quality.

(*b*) Composition of Green Millet.

Numerous analyses of this material have been made, the more recent ones by this department being tabulated as follows: —

* See, in the different reports of the Massachusetts Agricultural College and Hatch Experiment Station, the articles by Prof. W. P. Brooks, to whom we are indebted for the introduction of these fodder plants. See also Farmers' Bulletin, 101, published by the United States Department of Agriculture, on millets.

I. Water-free Material (Per Cent.).

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
(*a*) First week of blossom,*	–	7.84	8.44	32.06	49.92	1.74
(*b*) Second week of blossom,*	–	8.59	11.00	35.03	43.65	1.73
(*c*) Well headed,†	–	10.18	10.73	34.48	43.05	1.56
(*d*) Beginning to head,†	–	8.36	6.77	36.69	46.78	1.40
Average,	–	8.74	9.23	34.56	45.85	1.62
Corn fodder for comparison,‡	–	5.20	9.70	21.30	60.60	3.20

* (*a*) and (*b*) grown in same year on same plot.
† (*c*) and (*d*) grown in different years.
‡ Flint varieties, average forty analyses, Jenkins' and Winton's tables.

II. Average Results, Natural Moisture (Per Cent.).

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Millet,	80.00	1.75	1.85	6.91	9.17	.32
Corn,	79.80	1.10	2.00	4.30	12.10	.70

As is to be expected, the different samples of millet vary somewhat in composition, depending upon the stage of growth, weather conditions, fertility of land and possible errors in sampling. The natural tendency is for the fibre to increase as the plant approaches maturity.

Of the total crude protein in sample (d) (6.77 per cent.), 6.02 per cent. was found to exist as true albuminoids and .75 per cent. in the form of amids. The amids thus represented 12.46 per cent. and the albuminoids 87.54 per cent. of the matter calculated as crude protein. This is what might be expected in immature material of this character. The same sample showed 22.46 per cent. of pentosans, representing about one-half of the non-nitrogenous extract matter. It is quite probable, however, that a small quantity of the total pentosans still remained in the crude fibre and could not be counted as extract.

When the analysis of the millet is compared with that of corn fodder, on the basis of dry matter, one striking difference is noted, namely, that the fibre is much in excess in the

millet, and the nitrogen-free extract matter correspondingly less. The millet naturally develops relatively more woody matter than the corn, and for this reason it is necessary to cut the millet for feeding purposes while in blossom. If allowed to grow until the seed is developed, the straw is hard and woody, and quite unsatisfactory for feeding. Corn fodder, the analysis of which is given above, is supposed to be rather thickly seeded corn, with ears more or less developed, and probably cut late in August. It is an advantage to allow the corn fodder when fed green to grow until it has reached the above stage, for the reason that its digestibility and palatability are not appreciably decreased, while the nutritive value is considerably enhanced because of the ear development. The character also of the extract matter in the two fodders is not the same, the corn having a considerable amount of the valuable starch, which is practically lacking in the millet. The principal difference, then, from a chemical stand-point, between these two plants, consists, in case of the corn, in the extra percentage of nitrogen-free extract matter containing considerable quantities of starch, and the smaller percentage of the less valuable woody fibre. The protein percentage is about the same. The millet shows relatively rather more ash than the corn. This may be due to the fact that it is cut at an earlier stage in its growth. From the comparative chemical analysis of the two plants, as given above, one would naturally expect a greater nutritive effect from the corn than from the millet.

Composition of the Ash (Dry Matter).

Only two analyses of the ash of the millet are on record. One of them was made a number of years ago, and is very incomplete; the other represents a recent analysis of sample (d) : —

SAMPLES.	Crude Ash.	Soluble Ash	Insoluble Ash.	Calcium Oxide.	Potassium Oxide.	Phosphoric Acid.	Undetermined.
Sample (d), .	8.36	6.33	2.03	.96	3.70	.52	1.15
Earlier sample, .	–	–	–	–	1.96	.44	–
Green corn,* .	6.12	5.00	1.12	.82	2.18	.60	–

* From Wolff tables, given for comparison; exact stage of growth unknown.

The amount of the several ash constituents will of course vary, depending upon the state of growth, soil moisture and fertility. The above figures are not sufficient to enable one to form any very correct idea of the mineral constituents of the plant; they indicate, however, that the millet takes considerable quantities of mineral constituents from the soil, especially potash, and fully as much as Indian corn at a corresponding stage of growth.

Composition of the Seed.

SAMPLES.	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Millet seed (1898),	11.47	2.81	9.44	7.69	65.20	3.39
Millet seed (earlier),	10.30	3.10	12.30	7.70	60.90	5.70
Average of both samples,	10.88	2.96	10.87	7.69	63.05	4.55
Oats for comparison,*	11.00	3.00	11.80	9.50	59.70	5.00

* Jenkins's and Winton's tables, average 30 samples.

The millet seed resembles oats very closely in composition. The protein and fibre are a trifle higher in the oats, and the nitrogen-free extract correspondingly lower.

Composition of Millet Silage (Natural Moisture).

	Number Analyses.	Water.	Ash.	Protein.	Fibre.	Nitrogen-free-Extract.	Fat.
Millet,	3	74.0	2.40	1.70	7.50	13.60	.80
Millet and soy beans,*	9	79.0	2.80	2.80	7.20	7.20	1.00
Millet and soy beans,†	2	81.0	2.21	2.04	6.66	7.44	.65
Corn and soy beans,*	4	76.0	2.40	2.50	7.20	11.10	.80
Corn and soy beans,†	1	75.0	1.80	2.35	7.06	13.19	.60
Corn silage for comparison,‡	99	79.1	1.40	1.70	6.00	11.00	.80
Dry Matter.							
Millet,	3	–	9.24	6.50	28.80	52.36	3.10
Millet and soy beans,	11	–	13.06	12.91	34.40	35.07	4.56
Corn and soy beans,	5	–	9.42	10.20	29.63	47.59	3.14
Corn silage for comparison,	99	–	6.60	8.00	28.70	53.00	3.70

* Previous to 1897; approximately two-thirds millet or corn and one-third bean.
† During 1897. ‡ Jenkins's and Winton's tables.

The millet silage and the corn silage, so far as the above figures are concerned, show no great analytical differences. It must not be forgotten, however, that the non-nitrogenous extract matter of the corn contains a considerable amount of starch, which fails in the millet. The mixtures made from millet and corn, with soy beans, were not perfect. The object was to add one-third beans and two-thirds corn in putting the materials into the silo, but this was done only by loads of material and not by actual weight. The analytical results on the basis of dry matter are about what might be expected; namely, an increase in the protein percentage and a decrease in the extract matter in each case, when compared with millet or corn silage. One notes, however, more extract matter in the corn and bean than in the millet and bean silage. The protein and ash are higher in the millet and bean than in the corn and bean silage. This condition is satisfactorily explained on the ground that the millet and bean, being cut at an earlier stage than the corn and bean, would naturally contain relatively more ash and protein and less extract matter.

The Digestibility of Millet.

The following figures represent the digestibility of the different ingredients of millet, and were obtained by the use of sheep at this station. The numbers mean that, of the total amount of ash, protein, etc., contained in the millet, such and such amounts or percentages were digested. Thus, if green millet contains 6.91 per cent. of fibre, 73 per cent. of it is digestible, or $6.91 \times 73 = 5.04$ per cent.

CHARACTER OF MATERIAL.	Number Different Samples.	Number Single Trials.	Dry Matter.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Green millet, early to late blossom, . . .	1	3	71	61	69	73	72	64
Dent corn fodder (in milk) for comparison, .	3	9	70	–	61	64	76	78
Millet hay, full blossom,*	1	3	57	63	64	61	62	46
Millet hay, full blossom,†	1	2	56	24	31	63	55	50
Timothy hay for comparison, ...	12	26	67	–	48	52	63	60
Millet silage for comparison,‡	–	–	–	–	–	–	–	–
Millet and soy bean silage, ...	1	4	59	–	57	69	59	72
Corn and soy bean silage,§	1	3	69	–	65	65	75	82
Corn silage for comparison,‖	–	10	71	30	56	70	76	82

* Same plot as green material previously given.

† *Panicum italicum*, — a different species of Japanese millet.

‡ No digestion tests have been made.

§ Pride of North corn (dent) and medium green soy beans, two-thirds former and one-third latter, in excellent condition.

‖ Average dent and flint.

The green millet appears, from the figures at our disposal, to be as digestible as the fodder corn.

The millet hay shows a very much less degree of digestibility than the same material green. Generally speaking, the mere withdrawal of the water is not supposed to affect digestibility, and this is likely to be the case with young and tender plants and with grains that can be ground fine. In the case of coarse, woody plants the reverse is likely to be true. The hardening of the woody stalks in the curing process, and the less perfect mastication resulting, in all probability are the most important factors in bringing about this apparent result. We hope to make other experiments to still further prove this point. Unfortunately, no figures are on hand for the millet silage. The corn and bean silage shows about 10 per cent. more total digestible matter than the millet and bean silage. The extract matter of the former is noticeably more digestible. The high degree of digestibility of the extract matter of the corn and bean silage is explained when one remembers the considerable amount of corn grains present. Corn and soy bean silage, as shown

by this experiment, appears to be nearly as digestible as average corn silage, and the protein even more so.

Multiplying the percentage composition of the millet, as given in a previous page, by the digestion percentages or coefficients as stated above, one obtains the following percentages digestible in one hundred : —

[Figures equal percentages, or pounds in 100 digestible.]

CHARACTER OF MATERIAL.	Fresh or Air-dry Material.					Dry Matter.			
	Dry Matter.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Green millet, ...	14.20	1.28	5.04	6.60	.20	6.37	25.23	33.01	1.02
Green corn, fodder, . .	14.14	1.22	2.75	9.19	.55	5.91	13.63	46.06	2.50
Millet hay, ...	48.45	5.02	17.91	20.25	.63	5.90	21.08	23.84	.73
Timothy hay for comparison,	49.00	4.10	14.70	27.20	1.10	4.80	17.10	31.60	1.30
Millet and soy bean silage, .	12.15	1.51	4.90	4.27	.68	7.36	23.74	20.69	3.28
Corn and soy bean silage, .	16.70	1.60	4.66	8.64	.62	6.63	19.26	35.69	2.57
Corn silage for comparison, .	14.84	.95	4.20	8.44	.66	4.48	20.09	40.28	3.12

Millet hay is assumed to contain 15 per cent. of water and timothy hay 14 per cent. It is doubtful if the water content of the millet could be brought as low as 15 per cent.

The above figures tell the same story as those representing the *composition* of the several materials, namely, the excess of fibre and the lack of extract matter in the millet, as compared with the corn. While the green millet appears to be as digestible as the green corn, *there is more digestible fibre in the millet and correspondingly less digestible extract matter.* The corn silage shows rather less digestible protein than the millet and bean silage, and nearly twice as much digestible extract matter. There is not a great deal of difference between the corn and bean silage and the corn silage, excepting the increased amount of protein in the former.

Utility of Barnyard Millet.

Yield per Acre. — The millet is a heavy yielder of green fodder; from 12 to 18 tons per acre have been grown upon the college farm, on naturally moist land in good condition, while as high as 35 tons per acre have been reported by outside parties. Our own experience has shown it to yield from 12 to 14 tons per acre upon medium loam in good state of fertility, but not naturally very retentive of moisture. Such quantities, however, were produced without the millet appearing to suffer from lack of water; and it is believed that this amount is a conservative estimate of its productiveness, unless the land is especially moist, warm and fertile. If the millet is planted in drills 15 inches apart and allowed to mature, it will yield about 60 bushels of seed per acre, of an average weight of 35 pounds per bushel. When sown broadcast, 90 bushels per acre have been reported.

Millet as a Soiling Crop. — For use as a soiling crop, the seed should be sown broadcast and harrowed in May 10 to 15, at the rate of 12 quarts per acre. The fodder will be ready to cut August 1 or a few days earlier. It is wise to begin cutting before the heads appear, and to continue for twelve days. It cannot be cut to advantage for a much longer period, for the reason that after it is well headed it becomes tough and woody, and the animals refuse a portion of it. In order to secure green millet feed during the entire month of August, a second seeding can be made June 1, and a third about June 20. If green feed of this character is desired in September, later seedings are necessary. We have found it advantageous to sow peas with the first seeding of millet, at the rate of one and one-half bushels of Canada peas together with six quarts of millet per acre. The peas are first deeply harrowed in, and the millet covered with a tooth harrow. If the weather should prove cool during May and June, the peas are likely to get ahead of the millet, but the latter catches up as the warm weather comes on. This pea and millet mixture makes a desirable green feed. No experiments have been made to measure the feed-

ing value of green millet for milk production, for the reason that the time in its growth when it is available is too short to secure any very reliable data. We have fed the green millet to the station herd during the first three weeks of August for a number of years. During the first week of the cutting the animals eat it well, but the second week a considerable portion of the stems remain unconsumed. Millet acts as a laxative as well as a diuretic, and it is not advisable to feed it as the entire source of coarse fodder. Fed in this way, we have observed that the bowels become very loose, the animals soon refuse to eat above 60 pounds per day, and they lose in flesh and milk production. When they are fed entirely in the barn or yard, 10 pounds of hay per day, together with what green millet they will eat, is a desirable quantity. This usually amounts to about 50 or 60 pounds of millet daily. When animals run in pastures, a supplementary feeding of green millet at night is quite helpful.

From our observations we prefer corn fodder to millet as a green feed, because more milk is secured and the animals tend to keep in better condition. The corn fodder can be fed for a longer period than the millet, and, being more or less eared, its nutritive value is thereby enhanced. Millet, on the other hand, has the advantage of requiring less labor to grow than corn, as after it is once sown it requires no further attention until ready to cut.

Millet as a Hay Crop. — Brooks,* a number of years since, called attention to the fact that, although the yield of hay was from 3 to 6 tons per acre, the difficulty of properly curing it was such that the millet could not be very satisfactorily utilized as a hay crop. We can simply confirm this. The coarseness of the fodder renders it very difficult to eliminate sufficient of the water to enable the hay to keep well unless several extra hay days follow one another; the hay therefore is likely to become musty and consequently unsatisfactory for feeding, and the farmer cannot depend upon it as a rule to furnish him with any considerable amount of dry fodder.

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* *Loco citato.*

Millet as a Grain Crop. — According to Brooks,* the birds have a great liking for the seed and it is therefore difficult to harvest without loss. The yield of one ton to the acre is small, as compared with an average crop of corn. Brooks and Smith fed millet meal to four dairy cows, comparing it to an equal quantity of ground oats, and noted no difference in the results (experiment not published). The cost of threshing the grain is to be considered, and the straw would be quite inferior to corn stover for fodder purposes. It does not seem probable that the grain could be made an economic feed for farm animals.

Millet for Silage. — Millet makes a very fair silage, but, as a result of the writer's experience, it is not considered equal to maize. So far as known, there are no exact feeding experiments on record comparing these two plants for silage purposes. It lacks the large quantity of digestible starchy matter which the corn contains in the form of the grain. It could not be put into the silo after it had ripened its seed, as is the case with corn, for the straw would then be dry and tough, and the seed is covered with a hard seed-coating. Our observations have convinced us that millet silage has less nutritive effect than corn silage. The digestion experiments with millet and bean silage, as compared with corn and bean silage, confirm this opinion. We have also noticed that animals are inclined to consume a larger quantity of corn than of millet silage, especially when fed for a considerable length of time. While the labor involved in growing a crop of millet is certainly less than in growing a crop of corn, the extra work in harvesting the former for the silo makes up for it, at least to a considerable degree. If for any reason, however, the corn crop should fail, and millet could be advantageously grown, it would certainly make a very desirable substitute for the former. Millet and soy bean silage is preferable to millet silage, from a nutritive stand-point; but the cost of growing and harvesting the same prevents its general use.

The following estimate of the value of millets on the farm is made in Farmer's Bulletin, 101, already referred to, and

* *Loco citato.*

it so fully expresses the writer's estimate of the utility of barnyard millet that it is quoted in full: —

On the whole, it is doubtful if there are many sections in this country where millets should be made a primary crop. Their place is rather that of a supplementary one, — a "catch-crop," when the corn has been destroyed by hail or otherwise; a substitute for corn, where that crop is not easily grown; a crop to be grown on a piece of land that might otherwise lie idle; a readily available crop for use in short rotations; an excellent thing to grow on foul land, to get rid of weeds, giving practically the same results as fallowing or summer cultivation, and in addition a crop of forage; a supplement to the regular and permanent pastures and meadows. It is in such ways that the millets are most valuable on the average farm, and such is the place they should be given in American agriculture.

C. — DRIED DISTILLERY GRAINS.

What They are. — Dried distillery grains consist of the residue remaining in the process of manufacturing alcohol, spirits and whiskey from the several cereals. Briefly stated, the process consists in grinding the various grains employed and heating them with a solution of malt, thus converting the starch into sugar. The addition of yeast converts the sugar into alcohol, which is then distilled, and the residue or distillery slop is filtered, dried in especially constructed driers and put upon the market as a cattle food. It consists chiefly of the hulls, germ and protein of the grains. It has a more or less sour taste and smell, because of the fermentation. If the slop remains undried too long, this sour condition is increased. Well-informed parties state that the quality of the dried grains depends, in the first place, upon the composition of the distillers' mashes (*e.g.*, the kinds and proportions of the grains employed); secondly, upon the distillers' mode of mashing and fermenting; and, thirdly, somewhat upon the process of drying.

How They may be classified. — The dried grains may be classified as follows, depending upon the source from which they are derived: —

A. Alcohol and spirits grains.
B. Bourbon whiskey grains.
C. Rye whiskey grains.

The grains produced from *alcohol and spirits distilleries* are the highest in quality, and of the most uniform grade. Corn is practically the only grain used.

The grains produced by *whiskey distilleries* vary according to the proportion of corn, rye and malt contained in their mashes. The larger the proportion of corn and the smaller that of rye and malt (small grain, so called), the higher the grade of dry grains produced. Some bourbon whiskey distillers use very little "small grains," and their product stands near that of Class A. Many make bourbon, half rye and pure rye whiskey alternately in one season, and their product of dried grains varies in quality accordingly. Others, especially in Pennsylvania and Maryland, produce rye grains only.

Their Average Composition. — A large number of analyses of Class A grains are said to show an average of 35.33 per cent. of protein and 11.25 per cent. of fat.

Class B, or bourbon whiskey grains, run from 23.9 to 38.06 per cent. of protein and from 6.3 to 15 per cent. of fat.

Class C, or rye grains, show from 17.85 to 24.28 per cent. of protein and from 5.04 to 7.5 per cent. of fat, averaging 20.87 per cent. protein and 6.32 per cent. fat.

Where manufactured. — The grains derived from spirits and alcohol are manufactured chiefly in Illinois and Indiana, those from bourbon whiskey in Kentucky, and those from rye whiskey in Pennsylvania and Maryland. All grades are produced in Ohio and Wisconsin.

The Yearly Product. — According to the last annual report of the commissioner of internal revenue (page 104),

there were used in the distilleries of the United States during the fiscal year ending June 30, 1900: —

Bushels corn,	16,277,034
Bushels rye,	4,070,861
Bushels malt,	2,721,124
Bushels wheat,	27,225
Bushels oats,	15,414
Bushels barley,	1,328
Bushels mill feed and other materials,	1,276
Bushels grain of 60 pounds,	23,114,262

At present the annual output of distillers' dried grains in this country is less than 40,000 tons; but, if all the distillery slop were dried by perfect machinery, the country would produce about 170,000 tons yearly. The output of single distilleries varies from 1½ to 40 tons per day. Alcohol and spirits grains are produced in the largest establishments, which are generally operated throughout the year. Bourbon and rye whiskey grains are produced in smaller distilleries, rarely turning out more than 5 tons per day, and they are in operation only between November and July.

Where Distillers' Grains are consumed. — Very few grains have been thus far used in the United States, they being mostly exported and consumed in Germany. Statistics of the quantity exported have been lacking until recently, because of the classification employed. The export of distillers' dried grains, brewers' dried grains and malt sprouts, from July 1 to Oct. 31, 1900, was 22,347 tons, or about 5,600 tons per month. How much of this is distillers' dried grains is a trifle uncertain. It is estimated that the exports from July to October consisted of about 50 per cent. brewers' dried grains, 35 per cent. distillers' dried grains and 15 per cent. malt sprouts; that from January 1 to June 30 distillers' grains will predominate, and that the total export of the latter will amount to about 28,000 tons during the present fiscal year.*

* For the larger part of the above information we are indebted to the J. W. Biles Company, Cincinnati, O.

We understand it is the intention to introduce this material in our eastern markets. Our inspectors have already noticed it occasionally. For convenience in distinguishing the different qualities, the sellers have divided the various products into five grades, namely, "R," "X," "XX," "XXX" and "XXXX." Those marked "R" are lowest in protein and fat, and those marked "XXXX" highest. Some two years since, this department secured several tons of these grains. They were analyzed, tested for digestibility and fed to milch cows.

Composition of Distillers' Grains.

CONSTITUENTS.	Brand "R."	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."
Water,	7.00	7.00	7.00	7.00	7.00
Protein,	16.67	29.76	26.20	30.01	35.46
Fat,	5.68	10.88	9.77	11.90	10.04
Extract matter,	55.87	40.89	43.00	38.69	34.14
Fibre,	12.74	9.77	11.53	10.33	11.63
Ash,	2.04	1.70	2.50	2.07	1.73
Total,	100.00	100.00	100.00	100.00	100.00

The several grades showed between 7 and 8 per cent. of water; for the sake of uniformity, they were all calculated to a 7 per cent. basis.

The sellers state that the markings on "X" and "XX" must have been reversed, as the "XX" grains should show a higher percentage of protein than those marked "X." The "R" grains, as the sellers claim, are the poorest in composition, showing in this particular lot 16.67 per cent. of protein and 5.68 per cent. of fat, — about equal to the amounts found in wheat bran. The others gradually increase in these two ingredients, the "XXXX" showing 35.46 per cent. of protein and 10.04 per cent. of fat. The fibre is not excessive, being from 2 to 4 per cent. more than in bran. The analyses show these materials to be valuable feeding stuffs and worthy of the attention of feeders, providing they are sold on a guaranty. The sellers state that a guaranty will always accompany the different grades.

Digestibility of Distillers' Grains.

Digestion tests were made with sheep, and the following co-efficients obtained: —

CONSTITUENTS.	Brand "R."	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."	Average, excepting Brand "R."
Total dry matter,	58	87	84	76	77	81
Protein,	59	73	77	74	71	74
Fat,	84	93	95	93	96	94
Extract matter,	67	89	84	75	79	82

Excepting the "R" brand, these materials show relatively high digestibilities, with comparatively small variations. In the last column is given an average of the four "X" brands, which may represent the average digestibility of distillery grains made largely from corn.

Multiplying the composition by the percentages digestible, one obtains the *percentage or pounds in 100 digestible:* —

CONSTITUENTS.	Brand "R."	Wheat Bran for Comparison.
Dry matter,	53.94	54.29
Dry matter contains: —		
Protein,	9.84	12.60
Fat,	4.77	3.20
Extract matter,	37.43	35.40
Organic nutrients (excluding fibre) digestible,	52.04	51.20

The "R" brand appears to contain about the same quantity of digestible nutrients as does wheat bran. The latter contains rather more protein, and a trifle less fat and extract matter digestible than the former.

CONSTITUENTS.	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."	Gluten Feed for Comparison.*
Dry matter,	80.91	78.12	70.68	71.61	77.28
Dry matter contains: —					
Protein,	21.72	20.17	22.21	27.30	22.50
Fat,	10.12	9.28	11.07	9.64	3.30
Extract matter,	36.39	36.12	29.02	26.96	43.80
Organic nutrients, excluding fibre digestible.	68.23	65.57	62.30	63.90	69.60

* We refer to such well-known brands as Buffalo, Davenport, Rockford, being the residue from the glucose factories.

These several brands are quite similar in digestible ingredients to gluten feed, and for the present they can be considered as having approximately an equal value. They have noticeably more digestible fat and less digestible extract matter than the latter. They are likely to vary more in composition from time to time than the regular gluten feeds. The highest grade would probably contain rather more protein.

Tests with Milch Cows.

We were not in a position at the time to carry on any exact experiments with dairy animals. The several lots of grain were, however, fed to a number of cows, and the results were as good as one would naturally expect. The animals ate them well, receiving 3 or 4 pounds daily, mixed with wheat bran; the milk yield was satisfactory. We see no reason why the quality of the milk and butter should not be equal to that derived from animals fed upon corn silage, dried brewers' grains, etc. It would probably be wise not to feed such materials to animals when the milk was intended for infant feeding. Should these grains be generally introduced, it would be advisable to note particularly their influence, if any, on the flavor of milk and butter.

Several years since, a considerable quantity of so-called Atlas gluten meal was sold in Massachusetts and Vermont. This was dry distillery grains, sold by a distilling company in Peoria, Ill. It was not accompanied by a guaranty, and

varied from 22 to 36 per cent. of protein. It has not been in the market of late. Hills* fed this material (testing 35 per cent. of protein) to milch cows, and secured very satisfactory results. Its effect on the flavor of milk and butter was not mentioned, and we can assume it was satisfactory. He considered it the cheapest source of protein in Vermont markets at the time.

D.—DIGESTION EXPERIMENTS WITH SHEEP.

These experiments were made during the winter of 1898–99. The method employed was the usual one, as described in the eleventh report of the Massachusetts State Experiment Station for 1893. The full data will be published at another time. By digestion coefficients is meant the percentages of protein, fat, etc., that the animal is capable of digesting. Thus, if wheat bran contains 16 per cent. of protein, or 16 pounds in 100, and the percentage digestible or digestion coefficient is 78, it means that the animal can digest 78 per cent. of the 16 pounds, or 12.46 pounds.

Description of Feed Stuffs.

Hay. — This hay was used in connection with the several concentrated feeds. It was largely Kentucky blue grass, with a small admixture of red clover. It was cut in bloom.

Meadow Fescue. — This was grown on an experimental plot, on land in an average state of fertility. It was free from weeds or other grasses.

Kentucky Blue Grass. — Same conditions as for meadow fescue.

Tall Oat Grass. — Same conditions as for meadow fescue.

Distillery Grains. — Fully described on pages 44–50. The digestibility of the fibre varied to such an extent with the different sheep that no digestion coefficient is presented. It seems to be very digestible in the various "X" brands, possibly 75 or more per cent.

Oat Feed. — This food consisted of the refuse from the oatmeal mills. It was quite an inferior sample of its kind,

* Vermont Experiment Station report, 1895, p. 222.

containing a large quantity of hulls. The sheep digested only one-third of it.

Rye Feed. — This material is a mixture of rye bran, with a considerable quantity of fine middlings.

Chop Feed. — This consists of the hull, bran and broken germs of Indian corn, and is one of the residues remaining in the manufacture of starch and glucose. The sheep digested this material very unevenly, and the digestion coefficients given represent the average results from six sheep. They are not as satisfactory as could be desired.

Cleveland Flax Meal. — Linseed meal, with the oil quite thoroughly extracted by the naphtha process.

Parsons' "Six Dollar" Feed. — Fully described on pages 53, 54.

Digestion Coefficients resulting from Digestion Experiments.

KIND OF FEED STUFF.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Protein (Per Cent.).	Fat (Per Cent.).	Extract (Per Cent.).	Fibre (Per Cent.).	Ash (Per Cent.).
Hay, largely June grass in bloom (*poa pratensis*).	1	6	59	61	47	62	57	48
Meadow fescue, full bloom (*Festuca elatior pratensis*).	1	2	61	52	54	59	67	46
Kentucky blue grass, full bloom (*poa pratensis*).	1	1	56	57	42	53	63	42
Tall oat grass, late bloom (*Arrhenatherum elatius*).	1	2	55	51	56	58	55	41
Distillery grains, Brand "R,"	1	2	58	59	84	67	?	-
Distillery grains, Brand "X,"	1	2	87	73	93	89	?	-
Distillery grains, Brand "XX,"	1	2	84	77	94	84	?	-
Distillery grains, Brand "XXX,"	1	2	76	74	93	75	?	-
Distillery grains, Brand "XXXX,"	1	2	77	71	96	79	?	-
Oat feed (large amount hulls),	1	3	34	62	92	33	27	13
Rye feed,	1	3	82	80	90	88	?	35
Chop feed,	2	6	80	67	82	84	82	-
Cleveland flax meal,	1	2	87	83	76	94	?	21
Parsons' "six dollar" feed,	1	2	56	57	81	64	47	12

E. — THE COMPOSITION OF PURSLANE (*Portulaca oleracea*).

During the present summer this department received a letter from a Massachusetts farmer inquiring concerning the feeding value of purslane. He stated that he had been feeding it to his cows, and had noticed a decided increase in the quantity of milk; and that, while the animals at first refused to eat it, they soon became accustomed to it, and consumed considerable quantities daily. At the time we had no analysis of the material on hand, consequently a sample was procured and examined. Since making the analysis, we have found a similar analysis made by the Indiana station.* The results are presented below: —

	Green Material.						Water-free Material.				
	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Massachusetts station,	90.90	1.55	2.28	1.61	3.42	.24	17.08	25.11	17.71	37.44	2.66
Indiana station,	86.56	2.23	1.81	2.12	6.49	.50	–	–	–	–	–
Corn fodder for comparison,	79.80	1.10	2.00	4.30	12.10	.70	5.20	9.70	21.30	60.60	3.20

The analyses show that the plant contains a very large percentage of water, mineral constituents and nitrogenous matter (protein).

The Missouri station* found .29 per cent. of nitrogen, .85 per cent. of potash and .045 per cent. of phosphoric acid in the green matter, equivalent to approximately 2 per cent. of nitrogen, 6 per cent. of potash and .3 per cent. of phosphoric acid in dry matter. We have found .37 per cent. of nitrogen, equivalent to 4.1 per cent. of nitrogen in dry matter. The percentage of potash present in the Missouri sample is exceptionally large. The plants selected by us must have been in an earlier stage of growth than those of the Indiana and Missouri stations, for both the water and the protein content are very high.

* Farmers' Bulletin, 119, Department of Agriculture.

The above results show that purslane takes large quantities of water, nitrogen and potash from the land, and must be considered a great soil exhauster.

Plumb* has fed purslane to pigs with quite satisfactory results. If dairy animals can be induced to eat it, it would quite naturally increase the flow of milk, because of its high protein content. Whether it would produce any undesirable flavor in the milk, has not been observed.

It being a most objectionable weed where clean cultivation is desired, growing and spreading with wonderful rapidity, and being at the same time a large consumer of plant food, it would hardly be considered a desirable fodder crop on most farms. Whether it has any special ability to dissolve and utilize ordinarily insoluble plant food, has never been determined.

Purslane has been frequently used in many sections as a pot herb, being cooked in a similar way to spinach, etc. It is thus highly esteemed by many.

F. — PARSONS' "SIX DOLLAR" FEED.

The station frequently receives letters requesting information relative to the value of this material. We think Mr. Parsons himself quite fairly states in his circular what this feed is. He says: "It is composed principally of the hulls of different kinds of grains and other low-grade stuff from grain mills and elevators." A sample lot was procured for us by an outside party. In appearance it seemed to consist of the chaff of different grains. It analyzed as follows: —

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Parsons' feed, ...	11.00	7.90	9.99	17.89	51.10	2.12
Oat hulls for comparison, . .	14.30	10.00	4.00	34.00	36.20	1.50

It is quite evident from the above analysis that this sample of the feed contained a considerable quantity of hulls, chaff,

* Bulletin, 82, Indiana Experiment Station.

etc., because of the presence of so large an amount of fibre. It contained, however, in addition, other grain refuse and sweepings, for there is considerable more protein and extract matter than would be found in clear hulls.

The material was fed to sheep, to ascertain its digestibility. These animals were induced to eat it after a little effort. The figures following represent the *percentages digestible* of the total amounts of the several ingredients contained in the feed, and are termed digestion coefficients : —

	Dry Matter.	Ash.	Protein.	Fibre	Nitrogen-free Extract.	Fat.
Parsons' "six dollar" feed, .	56	12	57	47	64	81
Oat hulls for comparison,. .	–	–	35	57	45	35

This lot showed a degree of digestibility approaching average late-cut English hay, and superior to oat hulls. How much different lots are likely to vary in quality, we cannot state. Considerable difference in quality would naturally be expected.

We endeavored to feed this material to cows, as a partial hay substitute, but the animals could not be induced to eat it. This was in the spring of the year. It is possible that in the winter some of it might have been consumed with satisfactory results. It is dry, possesses considerable fertilizing value, having 1.60 per cent. of nitrogen, and is chiefly useful as an absorbent. We have not determined its content of phosphoric acid and potash. Oat hulls show .45 per cent. of potash and .13 per cent. of phosphoric acid. A conservative estimate of its fertilizing value would be $3 per ton.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, SAMUEL W. WILEY, JAMES E. HALLIGAN.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1900.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 55; of these, 33 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 6 in Connecticut, 2 in Vermont, 2 in Rhode Island, 1 in Canada, 1 in Maine, 1 in New Jersey and 1 in Illinois.

Two hundred and forty-four distinct brands of fertilizer, including chemicals, have been licensed in the State during the year.

Four hundred and forty-three samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and seventy-two samples were analyzed at the close of November, 1900, representing 251 distinct brands of fertilizer. These analyses were published in three bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 65, March; No. 68, July; and No. 70, November, 1900.

The samples not already analyzed, together with others that may be collected before the first of May, 1901, will be examined with a view of being published in our spring bulletin. It has not always been possible to secure a complete list of the samples licensed in the State; but as thorough a canvass as possible is annually made, varying more or less the towns to be visited from year to year, as seems advisable to the inspector. The methods of sampling are those laid down by our State laws for the regulation of the trade in commercial fertilizers.

For the readers' benefit the following abstract of the results of our analyses is here inserted: —

	1899.	1900.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	16	15
Number with two elements above the highest guarantee,	27	24
Number with one element above the highest guarantee,	73	85
Number with three elements between the lowest and highest guarantee,	88	118
Number with two elements between the lowest and highest guarantee,	84	92
Number with one element between the lowest and highest guarantee,	58	43
Number with three elements below the lowest guarantee,	-	1
Number with two elements below the lowest guarantee,	19	11
Number with one element below the lowest guarantee,	68	50
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	7	5
Number with one element above the highest guarantee,	32	20
Number with two elements between the lowest and highest guarantee,	20	19
Number with one element between the lowest and highest guarantee,	27	6
Number with two elements below the lowest guarantee,	2	-
Number with one element below the lowest guarantee,	18	20
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	10	15
Number between the lowest and highest guarantee,	16	9
Number below lowest guarantee,	10	10

A comparison of the above-stated results of our inspection with the results of 1899 shows, with the exception of those fertilizers which are classed under (*b*) (where two essential elements of plant food are guaranteed), a marked superiority in favor of the samples analyzed in 1900.

From a careful scrutiny of the results of analyses published in the three bulletins during the year it becomes an easy matter for the farmer to intelligently select his fertilizers for the next year's consumption, always bearing in mind that the fertilizer costing the least per ton is not always the most economical fertilizer to buy, but rather the one that will furnish the greatest amount of nitrogen, potassium oxide and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1899 and 1900 (Cents per Pound).

	1899.	1900.
Nitrogen in ammonia salts,	15.0	17.0
Nitrogen in nitrates,	12.5	13.5
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade fertilizers.	14.0	15.5
Organic nitrogen in fine bone and tankage,	14.0	15.5
Organic nitrogen in medium bone and tankage,	10.0	11.0
Phosphoric acid soluble in water,	4.5	4.5
Phosphoric acid soluble in ammonium citrate,	4.0	4.0
Phosphoric acid in fine-ground fish, bone and tankage,	4.0	4.0
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.0	4.0
Phosphoric acid in coarse fish, bone and tankage,	2.0	3.0
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.0	2.0
Potash as sulfate (free from chlorides),	5.0	5.0
Potash as muriate,	4.25	4.25

The cost of some of the leading forms of nitrogen shows a marked increase, as compared with the preceding year, 1899.

The above trade values are based on the market cost, during the six months preceding March, 1900, of standard raw materials which are largely used in the manufacture of compound fertilizers found in our markets. The following is a list of such materials: —

Sulfate of ammonia.
Azotine.
Cotton-seed meal.
Linseed meal.
Bone and tankage.
Nitrate of soda.
Dried blood.
Castor pomace.
Dry ground fish.
Dry ground meat.
Dissolved bones.
Acid phosphate.
Refuse bone-black.
Ground phosphate rock.
High-grade sulfate of potash.
Sulfate of potash and magnesia.
Muriate of potash.
Kainit.
Sylvinite.
Crude saltpetre.

How to use the table of trade values in calculating the approximate value of a fertilizer: Calculate the value of each of the three essential articles of plant food (nitrogen, phosphoric acid and potassium oxide, including the different forms of each wherever different forms are recognized in the table) in one hundred pounds of the fertilizer, and multiply each product by twenty, to raise it to a ton basis. The sum of these values will give the total value of the fertilizer per ton at the principal places of distribution. An example will suffice to show how this calculation is made: —

Analysis of Fertilizer (Per Cent., or Pounds in One Hundred Pounds of Fertilizer).

Nitrogen, ...	4
Soluble phosphoric acid, ...	8
Reverted phosphoric acid, ...	4
Insoluble phosphoric acid, ...	2
Potassium oxide (as sulfate), ...	10

	Value per Hundred Pounds.	Value per Ton (Two Thousand Pounds).
Four pounds nitrogen, at 15.5 cents, ...	$0 62×20	=$12 40
Eight pounds soluble phosphoric acid, at 4.5 cents, . .	36×20	= 7 20
Four pounds reverted phosphoric acid, at 4 cents, . .	16×20	= 3 20
Two pounds insoluble phosphoric acid, at 2 cents, . .	04×20	= 80
Ten pounds potassium oxide, at 5 cents, ...	50×20	= 10 00
Value per ton, ...	. . . . .	$33 60

The following table gives the average analysis of officially collected fertilizers for 1900: —

Average Analysis of Officially Collected Fertilizers for 1900.

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.29	2.95	2.53	4.53	3.79	2.81	10.52	9.02	7.96	7.31	5.40	5.02
Ground bones,	5.06	3.30	2.79	.58	8.29	15.73	24.11	11.31	8.46	6.46	-	-
Tankage,	6.57	4.18	4.02	-	9.68	10.65	19.76	17.67	9.68	-	-	-
Dissolved bone black,	11.33	-	-	14.75	3.00	.53	18.25	16.00	16.32	15.54	-	-
Wood ashes,	4.59	-	-	-	-	-	1.84	1.00	-	-	6.59	4.75
Kainit,	1.35	-	-	-	-	-	-	-	-	-	12.90	12.00
Nitrate of soda,	1.17	15.75	15.22	-	-	-	-	-	-	-	-	-
Muriate of potash,	1.77	-	-	-	-	-	-	-	-	-	49.55	50.27
High-grade sulfate of potash,	.44	-	-	-	-	-	-	-	-	-	50.78	48.00
Sulfate of ammonia,	.47	21.15	19.00	-	-	-	-	-	-	-	-	-
Acid phosphate,	16.22	-	-	13.82	2.06	.12	16.00	15.00	15.88	13.15	-	-
Cotton seed meal,	5.70	7.64	7.00	-	-	-	-	-	-	-	-	-
Cotton hull ashes,	8.05	-	-	-	-	-	10.38	10.00	-	-	24.48	20.00
Sulfate of potash and magnesia,	2.25	-	-	-	-	-	-	-	-	-	24.04	[illegible]

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State of Massachusetts during the Past Year (May 1, 1900, to May 1, 1901), and the Brands licensed by Each.

Armour Fertilizer Works, Chicago, Ill.: —
- All Soluble.
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- High-grade Potato.
- Cape Cod Asparagus Mixture.
- Armour's Grain Grower.
- Bone Meal.
- White Bone Flour.
- Armour's Flower Food.

Wm. H. Abbott, Holyoke, Mass: —
- Animal Fertilizer.
- Eagle Brand for Grass and Grain.
- Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

Butchers' Rendering Co., Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

East India Chemical Works (H. J. Baker & Bro., proprietors), New York, N. Y.: —
- Castor Pomace.
- A. A. Ammoniated Superphosphate.
- Complete Potato Manure.
- Strawberry Manure.
- Complete Tobacco Manure

C. A. Bartlett, Worcester, Mass.: —
- Pure Ground Bone.

Berkshire Mills Co., Bridgeport, Conn.: —
- Complete Fertilizer.
- Potato Phosphate.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Farm and Garden Phosphate.
- Bowker's Hill and Drill Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato Phosphate.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Gloucester Fish and Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.
- Ground Bone.

Bradley Fertilizer Co., Boston, Mass.: —
- Bradley's X. L. Phosphate.
- Potato Manure.
- Potato Fertilizer.
- Complete Manure for Potatoes and Vegetables.
- Corn Phosphate.
- Breck's Lawn and Garden Dressing.
- Eclipse Phoshate.
- Niagara Phosphate.
- Fine-ground Bone.
- Muriate of Potash.
- Kainit.
- Double Manure Salts.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Brightman's Fish and Potash.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market-garden Manure.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's D. Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
Bay State Fertilizer.
Bay State Fertilizer, G. G.
Potato Manure.
Potato Fertilizer.
Great Planet Manure.
King Philip Guano.

Cleveland Dryer Co., Boston, Mass.: —
Cleveland Superphosphate.
Cleveland Potato Phosphate.
Cleveland High-grade Complete Manure.

E. Frank Coe Co., New York, N. Y.: —
High-grade Ammoniated Bone Superphosphate.
Special Potato Fertilizer.
Fish and Potash, F. P.
Gold Brand Excelsior Guano.
Tobacco and Onion Fertilizer.
Vegetable and Vine.
Bay State Phosphate.
Market-garden Special Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
Crocker's Ammoniated Corn Phosphate.
Crocker's Potato, Hop and Tobacco Phosphate.
Crocker's New Rival Ammoniated Superphosphate.
Crocker's General Crop Phosphate.
Crocker's Superior Fertilizer.
Crocker's Grass and Oats Fertilizer.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Cumberland Superphosphate.
Cumberland Potato Fertilizer.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
Potato and Root Crop.
Blood, Bone and Potash.
Fine Bone.
Potato Manure.
Animal Fertilizer.
Complete Ten Per Cent. Manure.
Nitrate of Soda.
Muriate of Potash.

John C. Dow & Co., Boston, Mass.: —
Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Liquid Plant Food.
Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
Canada Wood Ashes.

Farmers' Union Fertilizer Co., Peabody, Mass.: —
Corn King.
Market-garden Special.
Complete Potato Fertilizer.
Ammoniated Bone Fertilizer.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Northern Corn Special.
Vegetable, Vine and Tobacco.
General Fertilizer.
Grass and Oats Fertilizer.
Garden Special.

Thomas Hersom & Co., New Bedford, Mass.: —
Meat and Bone.
Ground Bone.

F. E. Hancock, Walkerton, Ontario, Can.: —
Pure Unleached Canada Hardwood Ashes.

Charles W. Hastings, Jamaica Plain, Mass.: —
Ferti Flora.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.
Tankage.

Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Animal Brand.
Swift's Lowell Potato Phosphate.
Swift's Lowell Lawn Dressing.
Swift's Lowell Market Garden.
Swift's Lowell Fruit and Vine.
Swift's Lowell Tobacco Manure.
Swift's Lowell Dissolved Bone and Potash.
Swift's Lowell Potato Manure.
Swift's Lowell Ground Bone.
Swift's Lowell Nitrate of Soda.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Celebrated Onion Fertilizer.
- Lister's Special Potato Fertilizer.
- Lister's High-grade Special for Spring Crops.
- Lister's Special Tobacco Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass.: —
- Tankage.

The Mapes Formula & Peruvian Guano Co., New York, N. Y.: —
- The Mapes Bone Manures.
- The Mapes Superphosphates.
- The Mapes Special Crop Manures.
- Sulfate of Potash.
- Nitrate of Soda.
- Tobacco Ash Constituents.

Geo. L. Monroe, Oswego, N. Y.: —
- Pure Canada Unleached Wood Ashes.

McQuade Bros., West Auburn, Mass.: —
- Pure Ground Bone.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Market Garden.
- Chittenden's Complete Fertilizer.
- Chittenden's Ammoniated Bone.
- Chittenden's Fish and Potash.

Pacific Guano Co., Boston, Mass.: —
- High-grade General.
- Soluble Pacific Guano.
- Potato Special.
- Nobsque Guano.

Packer's Union Fertilizer Co., New York, N. Y.: —
- Gardener's Complete Manure.
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato Fertilizer.
- Special Strawberry Manure.
- A. A. Brand.
- Star Brand Superphosphate.
- Pure Ground Bone.
- P. & P. Potato Fertilizer.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Corn Manure.
- Market-garden Manure.
- Grass Fertilizer.
- Pequot Fish and Potash.
- Havana Tobacco Fertilizer.
- Climax Phosphate.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Fertilizer for Oats and Top Dressing.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's Fairchild's Formula for Corn.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Potato Manure.
- Hubbard's All Soils and All Crops.
- Hubbard's Corn Phosphate.
- Hubbard's Raw Knuckle-bone Flour.
- Hubbard's Strictly Pure Fine Bone.

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex XXX Fish and Potash.
- Essex Potato Fertilizer.
- Essex Corn Fertilizer.
- Essex Complete Manure for Potatoes and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Fertilizer.
- Essex Tobacco Starter.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Around Fertilizer.
- Complete Potato and Vegetable Fertilizer.
- Complete Corn Fertilizer.
- Fish and Potash.
- High-grade Soluble Tobacco and Potato.
- High-grade Oats and Top Dressing.
- High-grade Grass and Grain.
- High-grade Tobacco Fertilizer.

Read Fertilizer Co., New York, N. Y. (D. H. Foster, general agent) : —
- Read's Standard.
- High-grade Farmer's Friend.
- Practical Potato Special.
- Bone, Fish and Potash.
- Samson.
- Potato Manure.
- Vegetable and Vine.

Lucien Sanderson, New Haven, Conn. : —
- Sanderson's Old Reliable.
- Sanderson's Formula A.
- Sanderson's Blood, Bone and Meat.
- Sanderson's Nitrate of Soda.
- Sanderson's Dissolved Bone-black.

Standard Fertilizer Co., Boston, Mass. : —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.
- Standard A Brand.

Thomas L. Stetson, Randolph, Mass. : —
- Ground Bone.

Henry F. Tucker Co., Boston, Mass. : —
- Original Bay State Bone Superphosphate.
- Special Potato Fertilizer.

Darius Whithed, Lowell, Mass. : —
- Ground Bone.
- Champion Animal Fertilizer.

The Wilcox Fertilizer Works, Mystic, Conn. : —
- Potato, Onion and Tobacco Manure.
- High-grade Fish and Potash.
- Dry Ground Fish Guano.
- Fish and Potash.

Williams & Clark Fertilizer Co., Boston, Mass. : —
- High-grade Special.
- Ammoniated Bone Superphosphate.
- Potato Phosphate.
- Corn Phosphate.
- Potato Manure.
- Special with ten per cent. Potash.
- Royal Bone Phosphate.
- Prolific Crop Producer.
- Fine Wrapper Tobacco Grower.
- Bone Meal.

M. E. Wheeler & Co., Rutland, Vt. : —
- Corn Fertilizer.
- Potato Manure.
- Havana Tobacco Grower.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.
- Electrical Dissolved Bone.

A. L. Warren, Northborough, Mass. : —
- Fine-ground Bone.

Sanford Winter, Brockton, Mass. : —
- Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass. : —
- Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.
3. Notes on sludge, its agricultural value.
4. Notes on phosphatic slag, as a source of phosphoric acid for manurial purposes.

1. Analyses of Materials sent on for Examination.

During the past season 237 materials have been received and the results of our examination have been published in detail in bulletins 65, 68 and 70 of the Hatch Experiment Station of the Massachusetts Agricultural College, together with the results of the official inspection of commercial fertilizers.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for analyses, and our publication of results merely refers to the locality from which they come. It is evident, from the increase each year of the number of materials sent in for analysis, that there is a growing interest taken in this work, and individuals are realizing the value of such chemical investigations.

The waste products of our industries are becoming from year to year more numerous and important. As the current modes of manufacture are constantly undergoing changes which affect seriously their commercial manurial value, frequent investigation of this class of materials cannot help but prove beneficial to the farmer, and hence arrangements are made to attend to the examination of these materials to the

full extent of our resources. This work is carried on free of charge to the farmers of this State, the results of analysis being returned in the order of the arrival of samples at the office. Below is given a list of materials received during the past season, which shows the general nature of the work: —

Wood ashes,	73	Acid phosphate,	1
Cotton-hull ashes,	8	Dissolved bone-black,	2
Brickyard ashes,	1	Dissolved bone,	2
Leather-scrap ashes,	1	Cotton-seed meal,	4
Lime-kiln ashes,	2	Castor pomace,	1
Lime refuse,	1	Cotton waste,	7
Muriate of potash,	3	Tobacco stems,	3
High-grade sulfate of potash,	2	Tobacco dust,	1
Sulfate of potash and magnesia,	3	Muck,	2
Kainit,	1	Peat,	1
Silicate of potash,	1	Soot,	1
Sulfate of ammonia,	1	Bat guano,	1
Nitrate of soda,	3	Cork dust,	1
Ground bone,	7	Kiln dust,	1
Raw bone flour,	1	Complete fertilizers,	13
Steamed bone meal,	1	Refuse from garbage plant,	1
Tankage,	5	Stable manures,	14
Dry fish meat,	2	Stable refuse material,	1
Florida rock phosphate,	1	Sludge,	7
Phosphatic slag,	1	Soils,	29
South Carolina rock phosphate,	2	Bug death,	1
Apatite,	1	Miscellaneous materials,	22

These, together with other manurial products common to commercial and agricultural industries, are carefully investigated, and the results of our examination are free to the farmers of the State. As our resources are limited, we have to request all farmers sending material for examination to prepay express charges.

2. Notes on Wood Ashes.

During the past year (1900) 30.8 per cent. of the materials sent on for analysis consisted of wood ashes, as against 24.4 per cent. the previous year (1899). The wood ashes sold for manurial purposes in our State are subject to official inspection, and the dealers in this commodity must secure a license to sell before they can legally advertise their article.

The goods must be sold on a guaranteed analysis, stating their percentages of potash and of phosphoric acid present, and this analysis must be fastened to each package or car that contains them. As the dealer is obliged only to furnish a guarantee of the amount of potash and of phosphoric acid present in the ashes, no objection can be raised regarding the amount of moisture, so long as the specified amount of these two elements is present.

Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and general character of the foreign matters are apt to seriously affect the weight of a given volume. The following table shows the general character of the wood ashes, so far as their chemical composition is concerned, that have appeared in the general markets during the season of 1900 : —

Analysis of Wood Ashes.

CONSTITUENTS.	NUMBER OF SAMPLES.	
	1899.	1900.
Moisture below 1 per cent.,	2	1
Moisture from 1 to 10 per cent.,	21	25
Moisture from 10 to 20 per cent.,	35	32
Moisture from 20 to 30 per cent.,	1	13
Moisture above 30 per cent.,	1	1
Potassium oxide above 8 per cent.,	4	1
Potassium oxide from 7 to 8 per cent.,	9	6
Potassium oxide from 6 to 7 per cent.,	13	12
Potassium oxide from 5 to 6 per cent.,	7	25
Potassium oxide from 4 to 5 per cent ,	19	14
Potassium oxide from 3 to 4 per cent.,	2	7
Potassium oxide below 3 per cent.,	2	7
Phosphoric acid above 2 per cent.,	4	6
Phosphoric acid from 1 to 2 per cent.,	43	62
Phosphoric acid below 1 per cent.,	10	4
Average per cent. of calcium oxide (lime),	34.10	32.51
Per cent. of mineral matter insoluble in diluted hydrochloric acid : —		
Below 10 per cent.,	16	15
Between 10 and 15 per cent.,	26	35
Between 15 and 20 per cent.,	7	12
Above 20 per cent.,	7	11

To assist our farmers in selecting the best quality of wood ashes in our market, it is desirable that those sending samples for analysis will state the name of the party of whom the goods were purchased and price per ton paid.

3. Notes on Sludge, its Agricultural Value.

The interest in the character of this class of materials and their value for manurial purposes is deservedly steadily increasing, judging from inquiries received at this office. As the source of the article as well as the mode of collecting the same may differ widely, it is but natural that no definite advice can be furnished without a special examination into the existing circumstances. The subsequent compilation of analyses of sludge, made at the request of farmers of the State, are published to increase a more general interest in the matter: —

Analyses of Samples of Sludge (Per Cent.).

[The five samples were received from Worcester, Mass. I., taken from bottom of basin, unpressed; II., taken from top of basin, unpressed; III., pressed sample, yellowish in color; IV., pressed sample, black color; V., pressed sample, reddish color.]

CONSTITUENTS.	I.	II.	III.	IV.	V.
Moisture at 100° C.,	65.99	63.59	54.98	68.15	53.11
Nitrogen,	.44	.38	.49	.36	.62

Analyses of Samples of Sludge (Per Cent.).

[I., Average complete analysis of the above five samples; II., sludge received from Worcester, Mass.; III., sludge received from Brockton filter beds (1899); IV., sludge received from Brockton filter beds (1900).]

CONSTITUENTS.	I.	II.	III	IV.
Moisture at 100° C.,	61.16	65.61	21.44	2.77
Phosphoric acid,	.39	.47	.86	.72
Potassium oxide,	.13	.07	.16	.06
Nitrogen,	.46	.58	1.31	1.27
Calcium oxide,	5.08	–	1.13	trace.
Ferric oxide,	6.50	–	–	–
Aluminum oxide,	2.05	–	–	–
Magnesium oxide,	2.19	–	–	–
Sulfuric acid (SO_3),	.44	–	–	–
Carbonic acid,	4.86	–	–	–
Chlorine,	trace.	–	–	–
Insoluble matter,	10.57	5.63	–	–

It will be seen from the above analyses that there is a great difference in the percentage of the fertilizing constituents present in the different samples. There remains, however, no doubt that these materials when properly studied furnish a valuable source of plant food, when they can be conveniently obtained, and supplemented by such ingredients as potash and phosphoric acid compounds, to render them more suitable for manurial purposes in case of different crops.

4. Notes on Phosphatic Slag as a Source of Phosphoric Acid for Manurial Purposes.

The phosphatic slag, sometimes called Thomas basic phosphatic slag, or odorless phosphate, in advertisements of dealers of commercial fertilizers, is obtained as a by-product in the conversion of phosphorus containing iron ores into phosphorus free metallic iron. Investigations regarding its fitness as an economical source of phosphoric acid for manurial purposes have received, from the date of its first production, the special attention of agricultural chemists and agriculturists of Germany and other European countries. Field observations in the United States date back, as far as the writer is informed, to the year 1888. Summing up the results of the past, it will be admitted that a genuine phosphatic slag, judiciously applied, has proved a valuable addition to our phosphoric-acid-containing manurial resources, and that its use is only limited by its supply at a reasonable cost.

The subsequent tabular statement may convey some more definite idea regarding the general character of the phosphatic slag tested at Amherst, Mass. : —

Analyses of Phosphatic Slag (Per Cent.).

[I., German phosphatic slag (sent on), 1887; II., English phosphatic slag (sent on), 1887; III., German phosphatic slag (imported for station use), 1888; IV., phosphatic slag received from England, 1888.]

CONSTITUENTS.	I.	II.	III.	IV.
Moisture at 100° C.,	.10	.37	5.08	.37
Ferric and aluminum oxides,	4.26	–	15.98	8.55
Total phosphoric acid,	31.51	18.91	21.05	18.91
Available phosphoric acid,	.19	5.93	–	–
Insoluble phosphoric acid,	30.32	12.98	–	–
Calcium oxide,	41.87	49.82	53.97	49.22
Magnesium oxide,	–	–	3.83	–
Insoluble matter,	13.74	5.06	–	5.06

Analyses of Phosphatic Slag (Per Cent.).

[I., bought for field experiments, 1894; II., sent on from Hatfield, Mass., 1893; III., sent on from Marshfield, Mass., 1893; IV., sent on from Amherst, Mass., 1893; V., sent on from Mansfield, Mass., 1900.]

CONSTITUENTS.	I.	II.	III.	IV.	V.
Moisture at 100° C.,	.47	1.12	.60	.63	.25
Ferric and aluminum oxides,	14.35	–	–	–	–
Total phosphoric acid,	19.04	18.40	19.45	18.42	19.80
Available phosphoric acid,	–	–	–	–	6.04
Insoluble phosphoric acid,	–	–	–	–	13.76
Calcium oxide,	46.47	49.00	61.30	48.27	52.93
Magnesium oxide,	5.05	–	–	–	–
Carbonic acid,	–	2.67	2.25	–	–
Potassium oxide,	–	.32	.52	–	.50
Insoluble matter,	4.39	7.20	5.12	5.53	–

The analyses of phosphatic slag in earlier years, as a rule, show lower percentages of ammonium citrate soluble phosphoric acid when subjected to the same current mode of treatment as other phosphatic fertilizers, — a circumstance due to the presence of a varying quantity of caustic lime, which caused a decomposition of the citrate of ammonia, and thus affected more or less seriously its power to dissolve the available phosphoric acid present. The recognition of this fact on the part of chemists has caused the adoption of a modification in the character and the concentration of the citrate of ammonia solution proposed by Dr. P. Wagner, which aims at a neutralization of the free lime. The determination of available phosphoric acid in phosphatic slag, by Wagner's method, for trade purposes is to-day generally adopted. As our above-stated analyses of phosphatic slag extend over a period of more than twelve years, the main interest in our results consists in the statement of the amount of total phosphoric acid found present.

Aside from these recent changes in the current modes of analyzing these phosphates, there has been introduced an important change in the manufacture of phosphatic slag for manurial purposes. As in the fertilizer trade, the valuation

of the phosphoric acid is based, as a rule, on the amount of available phosphoric acid present. Manufacturers of phosphatic slag have aimed at the production of a material which, by chemical analysis, will show the largest amount of available phosphoric acid; this result is obtained by fusing the slag at about 900° C. with sufficient quartz sand to change the free lime present into silicate of lime. The inventor of this process (G. Hoyermann) has published as an illustration the following results: —

Analyses of Thomas Phosphatic Slag (Per Cent.).

[I., analysis of Thomas phosphatic slag before smelting with quartz sand; II., analysis of the same material after fusing with quartz sand.]

CONSTITUENTS.	I.	II.
Calcium oxide (free lime),	11.00	.70
Silicic acid,	2 to 3	12.00
Available phosphoric acid (percentage of whole),	58.00	84.00

The general introduction of Hoyermann's process has changed the character of the phosphatic slag of earlier years materially. The phosphatic slag of to-day contains, in exceptional cases only, some free lime, not sufficient to charge any beneficial effect of the phosphatic slag on the crop raised to free lime present.

An imitation of phosphatic slag is reported as having been introduced in Sweden. It is obtained by fusing apatite with soda ash at from 700° to 800° C. No representative sample of this material has yet come to the writer's notice.

REPORT OF THE BOTANISTS.

G. E. STONE, R. E. SMITH.

The work of this division during the past year has consisted as usual in the investigation of various forms of plant disease, together with a large amount of correspondence, the preparation of results for publication, and miscellaneous botanical work. Bulletin No. 69, on "The rotting of greenhouse lettuce," was issued during the year, giving an account of the work on this subject, to which reference has been made in several recent annual reports of this station. The extent of the lettuce-forcing industry in this State makes the subject of this bulletin one of great importance, as the financial loss from this source has been a large and increasing one. Notably in the case of the disease known as the "drop," the least understood and the most destructive of these troubles, results have been obtained which show hitherto entirely unknown characteristics in the development of the organism which causes the trouble, on the basis of which knowledge a practical and efficacious treatment can be applied. Another result of no small importance has been the demonstration of the worthlessness of many so-called remedies.

Our greenhouses used for purposes of experiment have as usual been devoted to the study of problems connected with the forcing of vegetables, principally cucumbers, in addition to lettuce.

Aster Diseases.

During the past summer, work on the diseases of the China aster has been continued, upon a much more extensive scale than heretofore. Altogether some 15,000 plants were grown, and a great variety of experiments were conducted upon fertilizers, varieties, localities, time of planting, methods of

handling, etc. In one bed, 600 feet in length, were grown all the varieties of this plant obtainable from the leading seedsmen of the country, over 300 in all. This plant is very generally affected by a number of serious troubles, most prominent of which is a disease of a peculiarly obscure nature. No organism of any kind appears to be the cause of it, yet it has a very characteristic as well as destructive effect. Our most recent results indicate that the abnormal development is due to a disturbance of the assimilative (metabolic) functions of the plant. The conditions, however, which bring about this disturbance, seem, as shown by our results thus far, contradictory and obscure. At least three other diseases, all of a fungous nature, also attack the aster, with serious effects. These can be more readily understood, if not prevented. Complaint is made from all parts of the country of trouble in growing this popular flower.

Nematode Worms.

A peculiar disease on potted cuttings of perennial phlox was sent in during the past winter, which proved to be caused by a species of nematode, but quite different from that attacking the roots of many plants, to which this division has devoted considerable attention. This new form attacks the stem of the plant, causing there an abnormal enlargement, while the leaves are stunted or reduced to mere rudiments, and the plant generally dies. The worm causing the mischief is a slender creature of microscopic size, which embeds itself in the tissues of the stem, where it multiplies rapidly and produces the abnormal growth. The species is an undescribed one, though it appears to be the same as that mentioned by several writers as attacking the stems and leaves of plants. This is the only occurrence of the sort which we have known in this State, and from its nature it does not appear to be anything which will become generally prevalent or destructive.

Cucumber Mildew (*Plasmopara Cubensis*, B. and C.).

This mildew made its appearance in Massachusetts during the past autumn for the first time, so far as we are aware,

since 1889, when it was reported by Dr. Humphrey * as found in two distinct localities in the State. This time it is again reported as occurring upon greenhouse cucumbers in two entirely distinct and remote localities, namely, Beverly and Leominster, but we are not aware of its presence during the summer on out-door cucumbers, squashes or melons. The fungus occurs more commonly in the south, and even no further remote than Ohio and Long Island it has proved exceedingly disastrous to out-door crops. It is surmised by Professor Selby of Ohio that it persists in the south and works its way northward as the season advances. The notable results in Long Island, obtained by Stewart,† in spraying with the Bordeaux mixture cucumbers affected with this mildew, show that the disease can be practically controlled.

The fungus appears largely upon the under side of the leaf, as a downy mass, greatly resembling the downy mildew of the grape. It must not, however, be confounded with the common powdery mildew found so frequently upon the upper surface of cucumber leaves. It is, moreover, more disastrous than the powdery mildew, and on this account should not be neglected when found.

Russian Thistle in Massachusetts.

The first report of the finding of the Russian thistle in Massachusetts which has come to our notice is made by Mr. Wm. P. Rich.‡ Two plants were first observed by him on a railroad bank at Dedham, Aug. 22, 1897, and since that time the plants have shown a tendency to increase slightly. Mr. Rich states that on Aug. 4, 1900, he found in the same locality twenty plants. A few of them had spread three hundred feet from where first observed in 1897. The Russian thistle has been previously reported in New York and Rhode Island.

* Eighth annual report, Massachusetts Agricultural Experiment Station, p. 210.
† New York Agricultural Experiment Station Bulletin, No. 119, Geneva, N. Y.
‡ Rhodora, Vol. II., p. 204.

Influence of Chemical Solutions upon the Germination of Seeds.

It is well known that there are many chemical solutions which accelerate and retard the germination of seeds; it is also known that germinating seeds are very susceptible to changes in temperature and moisture, to variations in the degree and kinds of light, to the amount of oxygen they receive, to the influence of electricity, etc. It was our idea, in inaugurating these experiments, to determine to what degree seeds could be accelerated in their germination, and also to what extent their germinating capacity could be increased. Experiments in this direction have been carried on in this department since 1895, but they have been interrupted a number of times. These experiments have been directed along two lines, namely, a study of the influence of physical factors upon germination, and a study of the effects of different chemical solutions upon germination. The results of the former experiments have already been published, in a bulletin entitled "Electro germination;" while some of the results of the latter, which have been carried on by Mr. E. H. Sharpe, at one time a student in the college, constitute the subject of this article.

Any form of treatment capable of accelerating the germination of seeds possesses perhaps more scientific than practical value; but there are, nevertheless, some high-priced seeds which do not retain their germinating capacity very long, and, if the percentage of germination can be materially increased at a small expense, such a treatment would be worthy of practical consideration. It is not our purpose, however, to maintain, from the results shown in the following tables, that they warrant practical application.

The solutions selected for these experiments are those which are frequently found in seeds and seedlings; and it was thought that, by applying these solutions to the seeds for a certain number of hours, they might supply the deficiency in some essential constituent, and thus enable poorer and exhausted seeds to germinate. There are many seeds which do not retain the power of germinating very long; and it might be supposed that one cause of this had some

connection with the normal condition of the enzymes or ferments, which are essential for the conversion of certain seed products into available forms for germination. It is with this idea in mind that our experiments with solutions have been conducted; and the solutions selected have been those which are known to exist in many seeds and seedlings as ferments or enzymes, termed diatase, pepsin, trypsin and others, and amides, such as asparagin, leucin, etc. With the exception of diatase, all of the chemicals used in making these solutions were obtained from Mercks, the diatase being made up from malt. These experiments are by no means as complete as desired, but circumstances did not permit of their continuation at the time they were made.

Experiments with Asparagin Solutions.

Asparagin is a typical amide, found in connection with many seedlings and storage organs. During germination the amides increase in some instances to a considerable extent. Asparagin is especially abundant in leguminous seedlings, and is believed to play an important part in metabolism. The following tables, I. to V., represent the effects of asparagin solution upon different seeds which display considerable variation in their germinating capacity. One hundred seeds were used in all instances for each strength of solution, and the strength of solution varied in each experiment from .1 to 2 per cent. The seeds were soaked in asparagin twelve hours, after which they were rinsed with water and placed in Zurich germinators excluded from the light in a room with fairly even temperature. The number of seed germinating each day were taken out and recorded, no observations being made previous to twenty-four hours after placing them in the germinator. In many instances the number of observations have been omitted in the tables, to save space, and the percentages in the last columns give the final results. The relative gain, however, during this period, is practically the same as that preceding it. The seeds were in every instance left a few days or a week longer, in order to see if any more would germinate. We endeavored to select seed which did not show a high percentage of germination, but in every case this was not accomplished.

TABLE I. — *Showing the Effects of Asparagin Solutions upon the Germination of Alfalfa Seeds (Medicago sativa L.).*

Experiment A.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).			
	1 (24 Hours).	2.	3.	4.
Normal,	65	85	87	88
2 per cent.,	81	92	97	97
1 per cent.,	85	96	98	99
.5 per cent.,	64	88	97	98
.25 per cent.,	73	93	98	99
.1 per cent.,	75	97	99	100

Normal average (per cent.), ... 88.0
Asparagin average (per cent.), ... 98.6

Experiment B.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).	
	1 (24 Hours).	2.
Normal,	53	90
2 per cent.,	93	100
1 per cent.,	88	99
.5 per cent.,	95	100
.25 per cent.,	89	98
.1 per cent.,	88	100

Normal average (per cent.), ... 90.0
Asparagin average (per cent.), ... 99.4

Experiments *A* and *B* in the table show an acceleration in germination as well as a gain in the germinating capacity. Experiment *B* is a repetition of *A*. Both experiments lasted three days longer than indicated by the table, but no further germination occurred in either.

TABLE II. — *Showing the Effects of Asparagin Solutions upon the Germination of Rape Seeds (Brassica napus L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION.									
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	10.
Normal,	–	–	–	–	–	2	8	16	25	68
2 per cent.,	1	1	2	2	4	11	23	89	47	97
1 per cent.,	5	5	5	6	10	10	14	17	28	85
.5 per cent.,	5	5	6	6	10	16	22	31	41	86
.25 per cent.,	6	7	10	12	17	28	40	51	58	90
.1 per cent.,	1	1	1	1	3	7	25	36	49	86

Normal average (per cent.), ... 68.0
Asparagin average (per cent.), ... 88.8

This experiment lasted three days longer than indicated in the table, and, as no further germination occurred, the experiment was discontinued.

TABLE III. — *Showing the Effects of Asparagin Solutions upon the Germination of Canadian Field Pea (Experiment A) and Vetch (Experiment B) Seeds.*

Experiment A.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).		
	1 (24 Hours).	2.	3.
Normal,	3	98	100
2 per cent.,	12	98	100
1 per cent ,	18	100	100
.5 per cent.,	27	100	100
.25 per cent.,	12	100	100
.1 per cent.,	17	99	100

Normal average (per cent.), ... 100
Asparagin average (per cent.), ... 100

Experiment B.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).		
	1 (24 Hours).	3.	3.
Normal,	35	97	99
2 per cent.,	78	100	100
1 per cent ,	84	100	100
.5 per cent.,	71	100	100
.25 per cent.,	83	100	100
.1 per cent.,	89	100	100

Normal average (per cent.), ... 99
Asparagin average (per cent.), ... 100

On account of the especially good seed used in these experiments, the results merely show an acceleration, due to the asparagin.

TABLE IV. — *Showing the Effects of Asparagin Solutions upon the Germination of Buckwheat Seeds (Fagopyrum esculentum* Moench).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.
Normal,	1	36	60	65	71	71	71	71	71
2 per cent.,	1	42	71	76	77	77	77	77	77
1 per cent.,	–	30	67	71	77	80	80	80	80
.5 per cent.,	–	47	80	86	91	92	92	92	92
.25 per cent.,	–	32	64	68	72	75	75	75	75
.1 per cent.,	–	43	75	79	80	83	84	84	85

Normal average (per cent.), ... 71.0
Asparagin average (per cent.), ... 81.6

No change in the results were shown when experiment was allowed to remain two days longer.

TABLE V. — *Showing the Effects of Asparagin Solutions upon the Germination of Serradella Seeds (Ornithopus sativus).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	17.
Normal,	–	2	7	10	16	28	34	40	42	55
2 per cent.,	–	2	7	16	25	28	34	41	46	76
1 per cent.,	–	3	16	24	34	39	44	47	53	74
.5 per cent.,	–	4	13	23	26	32	39	48	52	68
.25 per cent.,	1	6	16	22	31	34	38	44	51	74
.1 per cent.,	1	4	10	21	29	35	41	47	52	82

Normal average (per cent.), ... 55.0
Asparagin average (per cent.), ... 74.8

The seeds in this experiment failed to germinate further than shown in the table. Another experiment showed a corresponding acceleration, and at the end of fifteen days, when no more seed would germinate, the normal gave 54 per cent. and the treated averaged 79 per cent. One experiment with asparagus seed showed an acceleration throughout, and gave for the normal 40 per cent., while the treated was 45 per cent., — a gain of little consequence.

In considering the results of asparagin experiments as a whole, we find that the average percentage of germination for the normals in five experiments was 74.5 per cent.; that for the treated, 88.6 per cent. When the average percentage of the normal is compared with the .5 per cent. asparagin solution, we obtain 88.8 per cent. for asparagin and 74.5 per cent. for the normal.

In experiments dealing with seeds showing a small germinating capacity, some allowance must be made for individual variation, and it is better to use a large number of seeds in such cases, or, what is better, to have the experiment repeated a number of times with each species. Four experiments, however, of one hundred seeds, possess more value than one where four hundred seeds are used. After due allowance has been made for individual variation, it will be observed that the asparagin exerts an acceleration upon the germination of certain seeds, and also increases their germinating capacity. The various solutions of asparagin used show no detrimental effect upon the seeds.

Experiments with Leucin Solutions.

Leucin, like asparagin, is an amide, and is found frequently in connection with the latter in germinating seeds and seedlings. The seeds were soaked twelve hours in different strengths of solutions, and then rinsed before placing them in Zurich germinators, as in the asparagin experiments. Tables VI. and VII. give the result of two experiments with leucin.

TABLE VI. — *Showing the Effects of Leucin Solutions upon the Germination of Buckwheat Seeds (Fagopyrum esculentum* Moench).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	11.
Normal,	–	20	56	68	72	72	72	72	72
1 per cent.,	–	20	61	68	70	72	73	73	74
.5 per cent.,	–	20	59	71	76	77	78	80	80
.25 per cent.,	–	11	51	64	71	74	74	75	80
.1 per cent.,	–	22	66	81	89	90	92	92	92
.05 per cent.,	–	21	61	74	76	78	78	79	80

Normal average (per cent.), ... 72.0
Leucin average (per cent.), ... 81.2

No further germination took place in the untreated seeds after the fifth day.

TABLE VII. — *Showing the Effects of Leucin Solutions upon the Germination of Alfalfa Seeds (Medicago sativa).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).				
	1 (24 Hours).	2.	3.	4.	5.
Normal,	43	87	90	90	90
1 per cent.,	43	90	93	95	96
.5 per cent.,	43	89	94	96	96
.25 per cent.,	46	95	98	98	98
.1 per cent.,	47	94	96	97	97
.05 per cent.,	51	95	98	98	98

Normal average (per cent.), ... 90.0
Leucin average (per cent.), ... 97.0

No further germination took place in the untreated seeds after the third day. Another experiment with alfalfa gave 89 per cent. for the normal and 98 per cent. for the treated seeds. The average of the three leucin experiments gave 83 per cent. for the normal and 92 per cent. for the treated. The various solutions of leucin had no injurious effect on the seeds.

Experiments with Pepsin Solutions.

Pepsin is a proteolytic ferment (enzyme), found in some seeds during germination, and is capable of converting non-diffusible proteids into diffusible ones. The seeds in the experiments shown in the two tables. VIII. and IX., were treated as in the preceding ones.

TABLE VIII. — *Showing the Effects of Pepsin Solutions upon the Germination of Crimson Clover Seeds (Trifolium incarnatum L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).						
	1 (24 Hours).	2.	3.	4.	5.	6.	7.
Normal,	9	21	25	27	27	28	28
5 per cent.,	9	22	29	31	33	36	36
2.5 per cent.,	10	19	26	30	35	39	43
1 per cent.,	17	26	31	37	39	40	42
.5 per cent.,	19	27	33	36	39	40	42
.25 per cent.,	16	23	31	36	39	41	43
.1 per cent.,	17	25	31	35	37	39	42

Normal average (per cent.), ... 28.00
Pepsin average (per cent.), ... 41 33

None of the seeds showed any further germination when left five days longer. Two other experiments with crimson clover were made: in one the normal seeds gave 22 per cent., the average of the treated seeds 38.6 per cent.; in the other, the normals were 22 per cent., while the average treated ones gave 33.8 per cent. The average of the three crimson clover experiments is: normal average, 24 per cent.; pepsin average, 34 per cent. The best results were obtained by the .25 per cent. solution in each experiment, and by comparing the results of this treatment we have for the normal averages 24 per cent. and pepsin averages 41 per cent.

TABLE IX. — *Showing the Effects of Pepsin Solutions upon the Germination of Cucumber Seeds (Cucumis sativus L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).											
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Normal, ...	–	47	51	52	53	53	53	53	53	58	58	58
5 per cent., ...	–	63	67	70	71	71	73	76	76	76	77	77
2.5 per cent., ...	–	54	67	68	70	70	71	71	71	71	71	73
1 per cent., ...	–	62	67	70	70	70	75	75	75	77	77	77
.5 per cent., ...	–	53	56	58	58	58	63	63	66	70	70	70
.25 per cent., ...	–	48	57	58	60	60	63	65	67	70	70	70
.1 per cent., ...	–	53	56	58	60	63	69	71	72	75	75	75

Normal average (per cent.), ... 58.00
Pepsin average (per cent.), ... 73.66

None of the seeds showed any further germination. Another pepsin experiment with cucumber seeds gave for the normal 51 per cent. and an average of the treated was 68 per cent. Two pepsin experiments with vetch (*Vicia sativa*) gave precisely the same percentages of germination for both the normal and treated seeds, and all of the solutions except the .1 per cent. (which accelerated germination) resulted in a retardation. Yellow lupine seeds (*Lupinus luteus*) treated with the various pepsin solutions were also retarded, and alfalfa seeds responded to pepsin but slightly. It is known that pepsin does not exist, or at least has not been detected, in some germinating seeds. Among these is the lupine, and, from the results of the foregoing experiments, it would

appear not to be present, or at any rate play a very unimportant role, in such seeds as vetch and alfalfa.

Waugh* obtained favorable results with pepsin on tomatoes and watermelon seeds, but not with radish seeds. In our experiments the seeds showed a slight tendency to mould by the use of pepsin.

Experiments with Diastase Solutions.

Diastase, the starch-converting ferment, is probably the most widely distributed enzyme in the vegetable kingdom, it being found in seeds and mature parts of plants, and usually increasing during the mobilization of reserved food materials. The official solution used by chemists was prepared for this experiment, and consisted of 10 grams of fresh, finely ground malt, mixed with 200 cubic centimeters of water. This we have roughly designated, for convenience, as a 5 per cent. solution, from which the other percentages were obtained. The methods of treatment follow those in the preceding experiments.

TABLE X. — *Showing the Effects of Diastase Solutions upon the Germination of Black Barley Seeds (Hordeum sativum* Jessen).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).					
	1 (24 Hours).	2.	3.	4.	5.	6.
Normal,	75	84	88	88	88	88
5 per cent.,	14	39	63	74	85	89
2.5 per cent.,	71	92	95	96	97	97
1 per cent.,	80	91	94	94	94	98
.5 per cent.,	82	95	96	97	98	98
.25 per cent.,	82	93	94	96	98	98
.1 per cent.,	81	96	96	96	96	97
.05 per cent.,	85	93	94	94	94	94

Normal average (per cent.), ... 88
Diastase average (per cent.), ... 95

* Tenth annual report, Vermont Experiment Station, pp. 106-111; also eleventh annual report, Vermont Experiment Station, pp. 290-295.

TABLE XI. — *Showing the Effects of Diastase Solutions upon the Germination of Upland Rice Seeds (Oryza sativa L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION IN DAYS.			
	1 (24 Hours).	2.	3.	4.
Normal,	–	–	–	28
5 per cent.,	–	–	1	32
2.5 per cent.,	–	–	2	32
1 per cent.,	–	–	5	43
.5 per cent.,	–	–	5	41
.25 per cent.,	–	–	6	39
.1 per cent.,	–	–	5	42
.05 per cent.,	–	–	2	48

Normal average (per cent.), ... 28.0
Diastase average (per cent.), ... 39.5

Two other experiments were made, with black barley and with wheat seeds; the results, however, are of no consequence, inasmuch as the treated seeds became mouldy. This troublesome feature constituted the worst drawback in all of the diastase experiments. Waugh experienced the same trouble in the use of many of his solutions. This difficulty does not lie in the sterilization of the germinating appliances, but in the use of the solutions, which constitute excellent media for mould development. We therefore made the practice of rinsing all of the treated seeds with water before placing them in the germinators, which process helps keep down the moulds, but in some cases the moulds would appear even after the seeds had been rinsed. The results obtained from the foregoing experiments have already been sufficiently explained, and no further comment upon them is necessary here. In conclusion, it may be stated, however, that the study of the effects of amides and ferments and other accelerated factors upon seeds still offers a field for investigation worthy of a much more serious consideration than that given here.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

During the year which has elapsed since the last report the entomological work of the station has been conducted as usual, and with satisfactory results. An increasing amount of correspondence shows that the people of Massachusetts appreciate the opportunities afforded them for assistance more than formerly, and are availing themselves freely of that assistance.

The addition of a very complete set of apparatus for the photography of insects and their work has already been of much advantage to the division, as photographs from life are now being made, for use in the entomological publications of the station. The equipment in this line includes an enlarging, reducing and copying camera, a Premo camera for field work and another for use in photomicrography, all of which, with the necessary accessories, are in constant use.

Last spring a bulletin on the grass thrips was issued from this division, being a presentation of the practical and economic portions of the paper on the same subject by Mr. W. E. Hinds, which was published as an appendix to the last annual report of the college; and other bulletins on various important subjects are now being prepared. A catalogue of the Coccidæ of the world is also in preparation, and will probably be ready for publication during the coming year. Several papers on injurious insects have been written by Dr. H. T. Fernald, and published by the secretary of the Board of Agriculture of Massachusetts.

Many of the entomological bulletins from different stations have been bound for preservation and more convenient reference, and a number of valuable recent publications have been added to the insectary library.

Insects of the Year.

The past year has witnessed few serious insect attacks in Massachusetts. Why this was the case is difficult to determine, though it is possible that weather conditions last spring were in a measure responsible. An early warm period, continuing long enough to produce some of the earlier changes in insects from their winter conditions toward those of spring was followed by a colder period, which, coming after the initial changes had been taken, caught the insects in a state where they were unprepared for it, and may have caused the death of so many as to reduce their numbers. How far this explanation holds, however, cannot be determined.

The San José Scale.

This most serious pest to fruit growers has been present in Massachusetts a number of years. When it first made its appearance in the State it was believed by many that it had reached about its northern limit of distribution, and that its injuries would not be likely to be serious on that account. Time has shown, however, that this is not the case, and that the scale can not only become a very serious pest here, but that it can survive a temperature of thirty degrees below zero. The past summer, perhaps because of its dryness, has been distinctly favorable to the rapid increase of the scale and to a correspondingly increased destructiveness. As early as July 19 currants were received at the station so thoroughly covered by the young scales as to make them unsalable, and during the fall apples and pears were received in a similar condition. Up to the present year it was not known that fruit in Massachusetts could be so injured by the scale as to prevent its sale, though fruit trees killed by it were met with frequently. Now, however, the scale has demonstrated its ability to attack the fruit itself in this latitude, and this must call the attention of fruit raisers to the necessity of giving the most careful attention to their trees, if they desire to sell their products.

The scale has now been received from thirty-seven different towns in the State, and in all probability it occurs in as

many more. It is believed to have been exterminated in three places and in several others to be under control, but, as it is being sent in from other States on nursery stock each year, it is but a question of time when it will be present in almost every orchard, and destroy many of our ornamental trees and shrubs as well. That this is more than a mere fear is shown by the remark of a nurseryman in another State recently, when refused a certificate of inspection because of the presence of this scale: "Well, I can fill my Massachusetts orders with this stock, any way."

Much of the correspondence of the division of entomology has been about this and the other common scales, and, as little literature on the subject has recently been published in this State, a bulletin is being prepared upon these insects and the best methods of treatment for them.

Seventeen-year Locust.

This interesting insect appeared last June on Martha's Vineyard in considerable abundance. As this is the only place east of Pennsylvania where the brood due in 1900 has been found, it seemed desirable to make investigations as to the accuracy of previous observations, and to ascertain, if possible, whether this isolated colony was holding its own. Through the kindness of Mr. George Hunt Luce of West Tisbury, the necessary information and specimens were obtained, from which it appears that the brood is a well-known one on the island, and was as much in evidence as ever this year.

Birch Bucculatrix.

During September the birches were seriously attacked by the caterpillars of this insect, causing the leaves to become brown and noticeable, even at some distance. The injury was most apparent in the southern half of the State, except in the Connecticut valley, where it extended northward nearly to the State line. In 1887, 1890 and 1892 this insect was very abundant and destructive in Massachusetts, and has been present in smaller numbers every year. As it does not attract particular attention generally, it is not im-

probable that little will be seen of it in 1901, or, if abundant, that it will appear in the northern portions of the State, which escaped this year.

Marguerite Fly.

This little pest was sent to the station in February, 1900, with the statement that it was destroying the marguerites in the greenhouses of the sender. Careful studies upon its life history and methods for its destruction were at once commenced, and are now nearly completed. A successful, easy and inexpensive treatment for it has been discovered, and it is hoped that the results of the work will soon be in readiness for publication.

Greenhouse Aleurodes.

This insect has also caused much destruction in greenhouses in the State during the past year, a loss of four thousand dollars having been reported in one case, the damage being to early tomatoes and cucumbers, which were completely destroyed. Thorough investigations of the structure and life history of this insect are now being carried on at the insectary, together with a search for methods which will ensure its control.

Fall Canker Worm.

Little has been published upon the life history of the fall canker worm. During the year this insect has been raised from the egg, and its various stages fully described, much being added to our previous knowledge of the subject.

Pea-vine Louse.

Less has been heard about this insect than in 1899, though it has caused considerable loss in several places in the State. Whether it will increase in importance during 1901 is at least doubtful.

Faunal Distribution.

The distribution of insects is one of great interest and importance. Many of our worst pests will in all probability never extend as far north as Massachusetts, where the climatic

conditions are unfit for their continued existence. Certain portions of the State, however, appear to be so different from others in these regards that some insects may thrive there while unable to live elsewhere. It is of the utmost importance, therefore, to be able to locate these regions and their approximate limits, that we may know what the range of new insect foes will probably be. To this task the entomological division is giving much attention, already with many interesting and valuable results.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

During the year, as in previous years, the work of this division has been mainly that of taking observations of the various features of the weather, and transcribing the records in convenient form for reference and preservation. With the report of last year were published the means of many of the records for a period of ten years. These results are now assumed to indicate normal conditions at this station, and the monthly means are compared with them, for the purpose of determining variation from the normal.

Bulletins of four pages each have been regularly issued at the beginning of each month, giving the more important daily records, together with mean monthly conditions and remarks on any unusual features of the month. The usual annual summary will be prepared and published with the December bulletin.

The New England section of the United States Weather Bureau has furnished daily, except Sunday, throughout the year the local forecasts for the weather of the following day, and the signals have been displayed from the flag staff on the tower. At the request of the section director, the weekly snow reports are being sent to the Boston office this season, as has been done the past few years.

The observations for the determination of the amount of soil moisture by the electrical method were started, but, owing to the failure of the apparatus to give any concordant results, the work was abandoned after an unsuccessful attempt to remedy the defects. The electrodes tried were those that last year gave fairly satisfactory results; the reason for their failure this year is not apparent. It is evident to the divi-

sion that further work with our present equipment would be unprofitable.

The true meridian established here two years ago has enabled the division to begin a series of observations on the declination of the needle. These observations are taken monthly, and the readings entered in the yearly record book. The results will be of value in deducing a formula for variation in declination for this locality, and also in making surveys with the compass.

The only addition to the equipment during the year consists of an "adder," for facilitating the computation of mean daily temperatures from the hourly readings on the Draper temperature chart.

At the opening of the college, in September, Mr. A. C. Monahan, the observer, retired from the division, and was succeeded by the assistant observer, Mr. C. S. Rice.

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural division of the experiment station has been carried on during the past year upon the same general lines as those which have been followed in recent years. The usual variety of problems has presented itself for experimental inquiry, and the work has been more extensive than in any previous year. As in previous years, a very large share of our attention has been directed to solving some of the many problems connected with the use of manures and fertilizers. Our experiments in this line employ three distinct methods, viz., plot experiments in the open field, experiments in cylinders plunged to the rim in the ground, and pot experiments. The results of the last two will not be discussed in this report.

Plot Experiments.

A considerable number of these has been carried out upon our own grounds. On these, we have used one hundred and sixty-five plots, varying in size from about one-fortieth of an acre in case of some experiments to two or three acres in others, the average size of the plots being perhaps about one-tenth of an acre. Fifty-five plots have been used in such experiments upon land hired for the purpose. The nature of the experiments carried out upon these plots will be made plain by the following statement: —

To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen, and the extent to which the introduction of a crop of the clover family can make the use of nitrogen unnecessary, — eleven plots.

To determine the relative value of muriate and of sulfate of potash used in connection with bone meal, — eleven plots.

To determine the relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen, and of muriate of potash and sulfate of potash as sources of potash for garden crops, — seven plots.

To determine the relative value of kainite, and of the muriate, high-grade sulfate, low-grade sulfate, carbonate, silicate and nitrate as sources of potash, — forty plots.

To determine the relative efficiency of equal money's worth of dissolved bone-black, ground South Carolina rock, ground Florida phosphate, Mona guano and phosphatic slag as sources of phosphoric acid, — six plots.

To determine the relative efficiency of equal quantities of phosphoric acid, furnished in the following materials: acid phosphate, dissolved bone-black, dissolved bone, fine-ground raw bone, fine-ground steamed bone, fine-ground South Carolina phosphate, fine-ground Florida phosphate, phosphatic slag, apatite, Navassa phosphate, — thirteen plots.

To determine the relative value of manure alone, as compared with a smaller quantity of manure and a moderate amount of potash, for the corn crop, — four plots.

To determine the relative value of mixtures of fertilizer materials, furnishing, on the one hand, nitrogen, phosphoric acid and potash in the same proportions as in average corn fertilizers, and a mixture of similar materials containing more potash, — four plots.

Soil test with mixed grass and clover, — fourteen plots.

Soil test and experiment to determine the effect of liming for onions, — twenty-four plots.

Experiment in manuring grass lands, — three plots.

Experiment to determine the value of nitrate of soda for the rowen crop, — twelve plots.

Experiment in the use of fertilizers for orchard trees, — five plots.

Experiment to determine the relative efficiency of manure hauled and spread as fast as made, compared with manure put into large piles and spread in the spring, — ten plots.

Alfalfa, on which the effect of liming the soil is being studied, occupies four plots.

One of the plot experiments upon hired land has for its object the determination of the value of nitragin, or germ

fertilizer, for various legumes, and includes forty plots; while fifteen plots in another locality have been used in a soil test with grass as the crop.

Most of the problems upon which we hope to obtain light by means of these experiments have engaged our attention for a number of years. As might naturally be expected, the results are somewhat affected by season, as well as by numerous other causes which are not fully under control. Results in some cases have varied to some extent from year to year, and such variation must always be looked for in experiments of this character. This variation, of course, renders interpretation of the results a matter of much difficulty. Moreover, from the very nature of the questions engaging our attention, it is necessary that the work should continue over a considerable series of years before conclusions of general interest and importance can be drawn. It does not, therefore, seem best to publish in full the details concerning any considerable number of these experiments. Attention, however, will be called to some of the conclusions which it is believed are fully warranted by the results, not of the past year alone, but of a continuous line of investigations touching these points, many of which have continued for ten or more years.

I. — The Relative Value of Manures furnishing Nitrogen.

The experiments on which the conclusions now to be stated are based have been carried out on Field A, and a detailed description of the plan of experiment followed will be found in our twelfth annual report. These experiments were begun in 1890, and the crops grown have been oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover and potatoes. As the result of these experiments, we have found, taking into account all experiments from the beginning of the work up to date, that the various manures supplying nitrogen rank in the following order: nitrate of soda, barnyard manure, sulfate of ammonia and dried blood. If we allow numbers to express the relative efficiency of these materials, their standing is as follows: nitrate of soda,

100; barnyard manure, 90; sulfate of ammonia, 89; dried blood, 86; the plots receiving no nitrogen, 68.

It should be pointed out: (*a*) That the figure for barnyard manure is probably not a correct indication of the relative efficiency of the nitrogen it contains, because barnyard manure supplies humus and considerable quantities of lime, magnesia and other minerals which are not supplied by the fertilizers used on the other plots. These constituents of the barnyard manure are in almost all cases useful. The crops where manure is used, therefore, stand relatively higher than the availability of the nitrogen alone would warrant. (*b*) It is important to point out, further, that the relative standing of the sulfate of ammonia is lower than it undoubtedly would have been had lime been more largely used. Before these plots were limed the crops in some years were almost an absolute failure. Comparing the yields on the sulfate of ammonia with those on the nitrate plots for the years only which immediately follow the application of lime, we find, representing the yield on the nitrate of soda as 100, that the yield of the sulfate of ammonia is 101. The conclusion is inevitable, that, if we are to depend upon sulfate of ammonia as a source of nitrogen, we shall be obliged upon many of our soils to occasionally use considerable quantities of lime in connection with it. Since, however, a given quantity of nitrogen in the form of sulfate of ammonia costs more than the same quantity in the form of nitrate of soda, it is evident that the latter should usually be preferred. The nitrate of soda, however, is not so readily used in mixture with other fertilizers, on account of its tendency to become moist. Such materials as sulfate of ammonia and dried blood are far more likely to remain dry, and can therefore be more readily incorporated with other materials in manufacturing fertilizers or in making home mixtures.

II. — Crops of the Clover Family (Legumes) as Nitrogen Gatherers.

This experiment is carried out in connection with the experiments to determine the relative value of different materials furnishing nitrogen on Field A. Both soy beans and

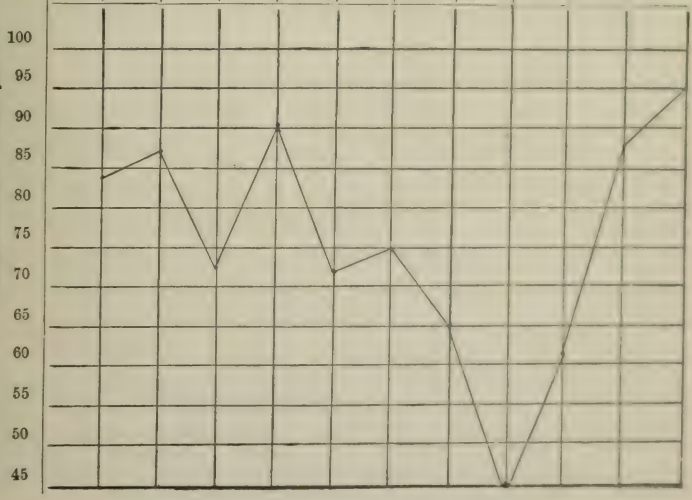
clover have been used, the former during three years, the latter one year; but it should be understood that the crops of both are harvested. We have aimed to test, not the effect of ploughing under these crops, but simply the improvement, if any, derived from their roots and stubble. The results indicate little or no improvement in the condition of the soil following culture of the soy bean, while a great improvement followed the turning under of the clover sod. The following table, with the curve below it, will, it is believed, make these facts clear: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

PLOTS.	1890. Oats.	1891. Rye.	1892. Soy Bean.	1893. Oats.	1894. Soy Bean.	1895. Oats.	1896. Soy Bean.	1897. Oats.	1898. Oats.	1899. Clover.	1900. Potatoes.
Nitrogen plots,	343	484	1,965	598	620	494	1,740	445	254	413	1,316
No-nitrogen plots,	290	421	1,443	540	452	370	1,143	197	158	367	1,254

[Per cent. average no-nitrogen to average nitrogen.]

1890. Oats.	1891. Rye.	1892. Soy Bean.	1893. Oats.	1894. Soy Bean.	1895. Oats.	1896. Soy Bean	1897. Oats.	1898. Oats.	1899. Clover.	1900. Potatoes.
84.5	87.0	73.5	90.5	72.9	75.0	65.7	44.3	62.2	88.9	95.3



Curve showing relation of average no-nitrogen to average nitrogen plots, the latter being considered in each year 100.

The plots, three in number, from which the average of the so-called no-nitrogen plots was obtained, have received no nitrogen-containing manure or fertilizer since 1884. The past season, therefore, is the sixteenth since these plots have been manured with anything containing nitrogen. The fact that after this long period potatoes on a clover sod give a crop amounting to 95.3 per cent. of that on plots which have yearly received a fair amount of manure or fertilizer containing nitrogen is certainly one of much significance, and strikingly illustrates the advantage which may be derived from the growth of clover under appropriate conditions. The actual yields of potatoes this year, although not large, were good; the no-nitrogen plots giving a yield at the rate of 209 bushels to the acre, and the nitrogen plots an average yield at the rate of 219.3 bushels per acre.

III. — The Relative Value of Muriate and High-grade Sulfate of Potash.

The experiments on which the following statements concerning relative value are based have been carried out on Field B, and have been in progress since 1892. The potash salts named are used in equal quantities, each continuously upon one-half of the plots, while all the plots have received a yearly application of fine-ground bone at the rate of 600 pounds per acre throughout the entire period. The potash salts were used yearly, at the rate of 400 pounds per acre, from 1892 to 1899. During the past year they have been applied at the rate of 250 pounds per acre. Full details concerning these experiments will be found in recent annual reports.

During the time that this experiment has continued the following crops have been grown on the field: potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. Crops have generally been good. Among these crops the potatoes,* clovers, cabbages and soy beans

* Potatoes have been grown upon our grounds under conditions making it possible to compare the yield of sulfate of potash with that of muriate of potash in fourteen different experiments; and as the average of all these experiments, if we represent the yield of sulfate of potash by 100, that of muriate is represented by the number 94.1, and in almost all instances the potatoes on the sulfate have been richer in starch and of better eating quality than those raised on the muriate.

have with very few exceptions done much the best on the sulfate of potash; while the yield of corn, grasses, oats, barley, vetches and sugar beets has been equally good on the muriate. The quality of the crops of potatoes and sugar beets produced by the sulfate of potash plots has been distinctly better than that of the crops produced on muriate of potash. Taking all the crops except the clovers into consideration, if we represent the efficiency of the high-grade sulfate of potash by the number 100, that of the muriate of potash is 98.1. Taking into account only those crops showing the preference for the sulfate of potash, and representing the efficiency of that salt by the number 100, the efficiency of the muriate of potash is 88.6. The present difference in price between the two salts is only about $5 per ton. The conclusion, therefore, appears to be warranted, that, under conditions similar to those prevailing in this experiment, the selection of the sulfate rather than the muriate is wise.

Further, in estimating the significance of our results, it should be kept in mind that the continued use of muriate of potash causes the loss with drainage waters of large amounts of lime. In the experiments on which the conclusions above stated are based we have yearly supplied a large amount of lime in the bone meal used, and accordingly the productiveness of the field even where the muriate of potash has been used has been fairly well maintained. Results on other fields on our farm indicate that when not used in connection with lime the muriate of potash stands much lower than the sulfate within comparatively few years. Whoever under ordinary conditions uses muriate of potash continuously, must sooner or later lime his land; and this is equally true, whether the farmer purchases muriate of potash and applies it by itself or in a home-made mixture, or if it is the source of the potash in a mixed fertilizer which he purchases. In deciding upon the purchase of any of the ordinary fertilizers upon the market, it is important to inquire whether the potash found in the fertilizer is present in the form of muriate or in the form of sulfate; and, other things being equal, the fertilizer containing its potash in the form of sulfate should be selected, unless the soil on which the material is to be

used is exceptionally light. The soil in the experiments on which the conclusions here presented are based is a medium loam. On a lighter soil the results would possibly be more favorable to the muriate.

As has been stated, the yield of the clovers has not been taken into account in making the calculations upon which the statements concerning the relative efficiency of the two potash salts are based. The reason why they have not been so taken into account is because there have always been more or less weeds produced among the clovers, and these have not been separated. The amount of weeds has naturally been greater in proportion as the clovers have been thinner and poorer. The figures, therefore, showing yields on the several plots in the form of hay, including the weight of the dried weeds as well as the weights of the dried clovers, do not correctly represent the effect of the fertilizers; accordingly, these figures have been discarded. There is, however, not the slightest doubt that in its effects upon the growth of the clovers the sulfate of potash stands distinctly ahead of the muriate. In some years and upon some plots the difference has been very large, at other times it has been smaller, and in a few instances the weight of the harvested product grown on muriate of potash has slightly exceeded that grown on the sulfate. It is without hesitation, however, that farmers are advised to employ sulfate of potash rather than the muriate, where good clover crops are desired, particularly unless prepared to use lime as well as potash salts liberally. If lime be liberally used, as indicated by our experiments on other fields, good clover can be grown on muriate of potash; but the combined cost of the lime and muriate will in most cases exceed the cost of the sulfate.

IV.—Field C.

A. The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The experiments upon which the conclusions now presented are based have been in progress since 1891, each of the several sources of nitrogen being applied yearly throughout the entire period upon the same plot. The crops grown

during this series of years have included spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn and celery, and each of these as a rule has been grown a number of years. Up to 1898, chemical fertilizers alone were employed in these experiments. During the past three years stable manure has been applied in equal quantities to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. Taking into account the period when chemical fertilizers only were used, and the crops (spinach, lettuce, onions, table beets, garden peas and early cabbages) whose period of growth is the comparatively early part of the season, we find the relative efficiency of the different materials used as the source of nitrogen: —

Nitrate of soda,	100.0
Dried blood,	86.6
Sulfate of ammonia,	83.6

For the same period, and taking into account those crops (tomatoes, garden beans and sweet corn) making much of their growth after hot weather fairly sets in, we find the relative standing as follows: —

Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	103.5

For the period since manure has been applied, and taking into account the early crops only (spinach, lettuce, table beets, onions, garden peas and potatoes), the relative standing is: —

Nitrate of soda,	100.0
Dried blood,	88.8
Sulfate of ammonia,	61.7

For the same period, taking into account the aggregate yield of all the late crops (tomatoes, cabbages, turnips, squashes and celery), the relative standing is: —

Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	91.9

With one exception, it will be seen that the nitrate of soda here, as in the case of the field crops, proves the most efficient source of nitrogen. Its superiority is, however, much more marked, as should be expected, because it is immediately available, for the early crops. For the late crops in one instance during the earlier years of the experiment the sulfate of ammonia exceeded the nitrate of soda in efficiency, but during the later years of the experiment it has stood behind, even for these crops. It should be stated, further, in comment upon these results, that on one-half the plots in these experiments muriate of potash is used in connection with the various nitrogen manures. The combination of sulfate of ammonia and muriate of potash, as has been repeatedly pointed out in former reports, is a bad one, owing to the possible formation and poisonous influence of chloride of ammonia. It should be further pointed out that this field has not received the application of any lime throughout the years during which it has been under experiment. The availability of the sulfate of ammonia would undoubtedly be increased by giving this soil a heavy dressing of lime, since the presence of lime promotes those changes which are essential to convert the nitrogen of the sulfate of ammonia into nitrates, which are the most readily available nitrogen compounds.

B. Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The period during which the experiments upon which the conclusions now to be stated are based and the crops grown are the same as in the case of the nitrogen fertilizers above discussed, and the relative standing of the two potash salts is shown for the same periods and crops.

Before Manure was used,—1891–97.

	Early Crops.	Late Crops.
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	91.3	91.5

After Manure was used, — 1898–1900.

	Early Crops.	Late Crops.
Sulfate of potash,	100.0	100.0
Muriate of potash,	86.1	98.8

It should be noted that the muriate of potash stands much below the sulfate for all the periods, its inferiority being particularly marked in the case of the early crops. This marked inferiority in the latter years of the experiment for the early crops is doubtless in considerable measure due to the fact that the yields of such crops on the one plot where the muriate of potash and sulfate of ammonia are used together, which has always been exceedingly small, with the progress of time appear to be growing relatively worse. This is doubtless due in some measure to the fact that the continued use of muriate of potash has caused the loss of considerable lime, — an effect which had been noted and reported in a number of previous years.

The yields on the muriate, it may be said in conclusion, could undoubtedly be brought much nearer those on the sulfate by heavily liming the field.

V. — The Relative Value of Different Phosphates. (Field F.)

The phosphates under comparison in this experiment (which was begun in 1890) have been applied on the basis of equal money's worth, the idea being to determine whether it is more profitable to employ cheaper natural phosphates or one of the higher-priced dissolved phosphates. The plan of the experiment has been outlined in previous reports. It is necessary to state here, for clearness only, the following points: —

The phosphates compared on the basis of equal money's worth are dissolved bone-black, ground South Carolina rock, ground Florida rock, Mona guano and phosphatic slag. These phosphates were liberally applied during four years

(1890 to 1893, inclusive). Since 1893 no phosphate has been applied to any part of the field. All plots from the beginning were liberally manured with materials furnishing nitrogen and potash, and this manuring has continued on an even more liberal scale since 1893. The amounts of phosphoric acid supplied the several plots, the basis being equal money's worth, have of course varied widely. They are as follows: —

	Pounds.
Plot 1, phosphatic slag, ...	96.72
Plot 2, Mona guano, ...	72.04
Plot 3, ground Florida rock phosphate, . . .	165.70
Plot 4, ground South Carolina rock phosphate, . .	144.48
Plot 5, dissolved bone-black, ...	49.36

The crop this year was cabbages, variety, Solid Emperor. The yield is shown in the following table: —

Comparison of Different Phosphates — Yield of Cabbages.

PLOTS.	Number over 2.25 Pounds.	Weight (Pounds).	Weight of Balance * (Pounds).
Plot 0, ...	3	8	95
Plot 1, ...	115	330	570
Plot 2, ...	73	250	580
Plot 3, ...	5	10	210
Plot 4, ...	111	550	950
Plot 5, ...	65	260	835

* Balance includes many small, hard heads, but too small for market.

The differences are very large, the ground South Carolina rock standing first, the phosphatic slag second, the Mona guano third, the dissolved bone-black fourth and the Florida phosphate last. The no-phosphate plot produced practically nothing. The plots are about one-seventh of an acre in area, and no plot has given what could be called a good crop. Last year the field was in oats, and there was but little difference between the yields of the different plots. The yield on all, even on the no-phosphate plot, was good.

In 1898 the crop on this field was corn, and the yield was good upon all plots except the no-phosphate plot and the

Florida phosphate plot, and there was no great difference between these yields. In 1897 the crop was Swedish turnips, and the relative growth on the different plots was about the same as this year in cabbages, the no-phosphate, the Florida phosphate and the dissolved bone-black giving the smallest yields, although the latter was not very much behind the balance of the plots.

Since the third year of the experiment the yields on the plots to which phosphatic slag, Mona guano and South Carolina rock phosphate have been applied have been substantially the same as on the dissolved bone-black plot, with the exception of the turnips and the cabbages, where the yields of these plots have been considerably greater than on the dissolved bone-black. All the crops grown upon the field, with the exception of the turnips and the cabbages, have given fairly good yields. The oat crop of last year was at the rate of about 40 bushels per acre; but even the no-phosphate plot gave practically the same yield as any of the others, so that the results with that crop really afford no light upon the particular question touched by this experiment. Taking into account all the crops which have been grown upon this field, except the Swedish turnips, which were affected by disease not apparently due to the fertilizer which had been used on a portion of the plots, and the yields of which, therefore, as expressed in figures, would be misleading, and representing the aggregate yield which stands highest by 100, the efficiency of the different phosphates is as follows: —

	Per Cent.
Phosphatic slag,	100.0
Ground South Carolina rock,	92.3
Dissolved bone-black,	90.7
Mona guano,	88.3
Florida phosphate,	71.5

There was at first no no-phosphate plot used in this experiment, but we have had a no-phosphate plot since 1895. Taking into account the yields of the several plots since 1895, and excepting the Swedish turnips, which were grown in 1897, for reasons above stated, the phosphates have the following relative rank: —

	Per Cent.
South Carolina rock phosphate,	100.0
Phosphatic slag,	99.0
Dissolved bone-black,	97.7
Mona guano,	95.4
Florida phosphate,	64.2
No-phosphate,	55.4

The crops which have been raised on the field in the order of their succession are as follows: potatoes, wheat, serradella, corn, barley, rye, soy beans, Swedish turnips, corn, oats and cabbages. All the plots in the field received an application of lime at the rate of one ton to the acre of quicklime, slaked, spread after ploughing and deeply worked in with a harrow in the spring of 1898.

This statement of the conditions of the experiment and of the relative yields on the different plots should perhaps be further supplemented by the statement that, supposing the crops harvested to have been of average composition and that there has been no waste, there would remain of the total phosphoric acid applied to the several plots the following amounts in each: —

	Pounds.
The phosphatic slag plot,	53.6
Mona guano,	29.7
Florida phosphate,	132.4
South Carolina rock phosphate,	102.0
Dissolved bone-black,	9.5

The following conclusions appear to be justified by the results which we have obtained: —

1. It is possible to produce profitable crops of most kinds by liberal use of natural phosphates, and in a long series of years there might be a considerable money saving in depending, at least in part, upon these rather than upon the higher-priced dissolved phosphates.

2. None of these natural phosphates appear to be suited to crops belonging to the turnip or cabbage family; but whether it is because these crops require the presence of an unusually large amount of soluble phosphoric acid, or whether it is because of some other effect of the dissolved phosphates, our experiments do not enable us to say. While we have obtained much the largest crops of turnips and cab-

bages on the natural phosphates, the yields have not been what could be considered good.

3. Between ground South Carolina rock, Mona guano and the phosphatic slag there is no considerable difference in the economic result.

4. The Florida phosphate, though used in amounts furnishing much more phosphoric acid than is furnished by either of the others, stands far behind them in yield, and would appear, therefore, to be rendered available only with extreme slowness.

In conclusion, it may be doubted whether, under the conditions prevailing in ordinary farm or garden practice, it would be wise to depend exclusively upon the natural phosphates. The best practice will probably be found to consist in using one of these in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

VI. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

The phosphates under comparison on this basis include apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Navassa phosphate, dissolved bone-black, raw bone, dissolved bone, steamed bone and acid phosphate. The experiments have been in progress three years, each phosphate being applied yearly to the same plot. There are three no-phosphate plots, which serve as a basis for comparison. The plots are one-eighth of an acre each in area.

During the past year two crops have been grown upon this field: oats, which were cut and made into hay; and Hungarian grass, also made into hay. The yields have been large on all plots, varying from a little less than 4 tons per acre for the two crops on the poorest no-phosphate plot to rather over 5 tons per acre for the two crops on the dissolved bone-black which gave the largest yield. The only points to which it seems desirable to call attention are the following: —

1. The phosphatic slag evidently furnished phosphoric acid in an exceedingly available form, the yield this year being almost equal to that on the dissolved bone-black.

2. The Florida soft phosphate is apparently a very inferior material, the phosphoric acid evidently becoming available only with great slowness.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

Soil Tests.

During the past season two soil tests have been carried out upon our own grounds, both in continuation of previous work upon the same grounds. The same kinds of fertilizers have been applied to each plot and in the same amounts as last year. The fertilizers in these experiments are used in accordance with the co-operative plan for soil tests adopted in Washington in 1899. Each fertilizer wherever employed is always applied at the following rates per acre: —

Nitrate of soda, . .	160 pounds, furnishing nitrogen.
Dissolved bone-black, .	320 pounds, furnishing phosphoric acid.
Muriate of potash, .	160 pounds, furnishing potash.
Land plaster, . .	400 pounds.
Lime, ...	400 pounds.
Manure, . . .	5 cords.

Soil Test with Grass (South Acre).

The past is the twelfth season that the experiment on this field has been in progress. The field has been cropped in successive years as follows: corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, corn, and this year grass and clover seeded in early spring. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer. Three plots have yearly received a single important manurial element, nitrogen, phosphoric acid or potash, every year the same; three have received each year two of these elements; one has received all three yearly; and one each has received, yearly, lime, plaster or manure. The larger part of the field accordingly has remained either entirely unmanured or has had but a partial manuring, and the degree of exhaustion of most of the plots is considerable. The four nothing plots this year produced an average at the rate of 930 pounds of hay per acre. The following table shows the rate of yield of the several plots: —

Effect of the Fertilizers.

Hay (South Acre Soil Test, 1900).

FERTILIZERS USED.	Yield per Acre (Pounds).	Gain or Loss per Acre, compared with Nothing Plots (Pounds).
Plot 1, nitrate of soda,	2,460	1,660.00
Plot 2, dissolved bone-black,	1,000	200.00
Plot 3, nothing,	800	-
Plot 4, muriate of potash,	1,140	366.67
Plot 5, lime,	880	133.33
Plot 6, nothing,	720	-
Plot 7, manure,	4,160	3,440.00
Plot 8, nitrate of soda and dissolved bone-black,	2,540	1,440.00
Plot 9, nothing,	1,100	-
Plot 10, nitrate of soda and muriate of potash,	3,000	1,900.00
Plot 11, dissolved bone-black and muriate of potash,	1,600	500.00
Plot 12, nothing,	1,100	-
Plot 13, plaster,	900	—200.00
Plot 14, nitrate of soda, dissolved bone-black and muriate of potash.	2,300	1,200.00

The effect of each of the three elements of plant food, nitrogen, phosphoric acid and potash, is more clearly brought out in the tables below: —

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Muriate of Potash.	Phosphoric Acid and Potash.	Average Result.
Hay (pounds per acre),	1,660	1,240	1,533.33	700	1,283.33

Value of net average increment, . . . $10 27
Financial result (gain), . . . 7 07

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Potash.	Average Result.
Hay (pounds per acre),	200	—220	133.33	—700	—146.67

Value of net average decrease, . . . $1 17
Financial result (loss), . . . 4 37

	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Phosphoric Acid.	Nitrate and Phosphoric Acid.	Average Result.
Hay (pounds per acre),	366.67	240	300	—240	166.67

Value of net average increment, . . . $1 33
Financial result (loss), . . . 1 87

	Results of the Addition to Nothing of —			
	Complete Fertilizer.	Manure.	Plaster.	Lime.
Hay (pounds per acre),	1,200	3,440	−200	133.33
Value of increment,	$9 60	$27 52	–	$1 07
Value of decrease,	–	–	$1 60	–
Financial result,	No gain or loss.	2 52 gain.	3 40 loss.	0.13 loss.

These results require little comment. A study of the figures shows that it is the nitrate of soda chiefly which causes an increase in the crop. Alone and in every combination it gives a large increase. It should be remembered, in estimating the significance of these figures, that the field was seeded last spring, and that accordingly the crop was comparatively small. The effect of the fertilizers will undoubtedly become more pronounced another season, when both grass and clover are fully established. *It is especially noteworthy that nitrate of soda alone applied to a plot which has now received no other fertilizer for twelve years gives a crop of hay amounting to almost* 1¼ *tons. This plot last year gave a crop of corn at the rate of something less than* 14 *bushels per acre. The plot to which muriate of potash alone has been applied during the past twelve years gave us last year a yield of corn at the rate of nearly* 50 *bushels per acre. The hay crop this year is* 1,140 *pounds.* These comparisons, bringing out the differing effects of the same fertilizer on the same field for different crops, and still other comparisons which might be made, illustrate in a striking manner the fact that the selection of fertilizers for our average soils should be made chiefly with reference to the crop.

All plots in this field were evenly seeded with a mixture of grass and clover seeds, sown crosswise, to insure even seeding of all plots. Both grass and clover seeds came up well, and the clover was thick at the start on all plots. At the present time there is practically no clover on any of the plots except the four to which potash has been applied and the one to which manure has been yearly applied.

Soil Test with Onions (North Acre).

This experiment is upon the land occupied last year in a similar soil test with onions. The field has been employed in soil test work for eleven years, the several plots having

been every year manured alike, as described under soil test with grass. The previous crops in the order of rotation have been potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions, and onions. It will be remembered that the west half of each plot was limed in the spring of 1899 at the rate of 1 ton per acre of quicklime, slaked, and immediately spread and harrowed in. The fertilizers were employed this year in the same quantities as last, viz. : —

	Pounds.
Nitrate of soda (per acre),	320
Dissolved bone-black (per acre),	640
Muriate of potash (per acre),	320

The seed was sown at the rate of 5 pounds per acre. The variety was Danvers' Yellow Globe. Germination was prompt and perfect, but many of the plants upon the nothing plots and upon the unlimed portion of the plots receiving respectively muriate of potash, nitrate of soda, nitrate of soda and muriate of potash, and dissolved bone-black and muriate of potash, soon died; while such plants as survived upon these plots made but very little growth. The following tables give the results of the harvest : —

Effect of the Fertilizers.

Onions (North Acre Soil Test, 1900).

Plot.	FERTILIZERS USED.	YIELD PER ACRE OF SCALLIONS AND TOPS (POUNDS).		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS (POUNDS).	
		Unlimed.	Limed.	Unlimed.	Limed.
1	Nothing,	460	1,600	-	-
2	Nitrate of soda,	3,100	1,780	1,640	20
3	Dissolved bone-black,	1,160	880	—1,300	—1,040
4	Nothing,	3,460	2,080	-	-
5	Muriate of potash,	3,200	3,400	—455	1,050
6	Nitrate of soda and dissolved bone-black.	1,720	760	—2,130	—1,860
7	Nitrate of soda and muriate of potash.	1,100	4,520	—2,945	1,630
8	Nothing,	4,240	3,160	-	-
9	Dissolved bone-black and muriate of potash.	5,320	1,720	1,500	—1,980
10	Nitrate of soda, dissolved bone-black and muriate of potash.	5,600	1,520	2,200	—2,220
11	Plaster,	1,760	1,960	—1,220	—2,070
12	Nothing,	2,560	4,320	-	-

Onions (North Acre Soil Test, 1900).

Plot.	FERTILIZERS USED.	Yield per Acre of Well-cured Onions (Bushels). Unlimed.	Yield per Acre of Well-cured Onions (Bushels). Limed.	Gain or Loss per Acre, compared with Nothing Plots (Bushels). Unlimed.	Gain or Loss per Acre, compared with Nothing Plots (Bushels). Limed.
1	Nothing, ...	6.15	41.54	-	-
2	Nitrate of soda, ...	50.00	155.00	21.67	83.21
3	Dissolved bone-black, . .	17.31	37.69	—33.20	—64.36
4	Nothing, ...	72.69	132.31	-	-
5	Muriate of potash, . . .	37.69	383.46	—26.45	257.31
6	Nitrate of soda and dissolved bone-black.	225.77	202.31	170.20	82.31
7	Nitrate of soda and muriate of potash.	9.23	310.77	—37.80	196.93
8	Nothing, ...	38.46	107.69	-	-
9	Dissolved bone-black and muriate of potash.	159.62	380.00	124.91	273.66
10	Nitrate of soda, dissolved bone-black and muriate of potash.	136.92	488.46	105.96	383.46
11	Plaster, ...	4.62	23.08	—22.59	—80.57
12	Nothing, ...	23.46	102.31	-	-

	Results of the Addition of Nitrogen to — Nothing.	Phosphoric Acid.	Muriate of Potash.	Phosphoric Acid and Potash.	Average Result.
Scallions, unlimed (pounds), .	1,640	—830	—2,490	700	—245
Scallions, limed (pounds), . .	20	—820	580	—240	—115
Onions, unlimed (bushels), .	21.67	203.40	—11.35	—18.95	48.69
Onions, limed (bushels), . .	83.21	146.67	—60.38	109.80	69.83

Value of net average increment: unlimed, $12.66; limed, $18.16.
Financial result: unlimed, $6.26 gain; limed, $11.76 gain.

	Results of the Addition of Phosphoric Acid to — Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Muriate of Potash.	Average Result.
Scallions, unlimed (pounds), .	—1,300	—3,770	1,955	5,145	507.50
Scallions, limed (pounds) . .	—1,040	—1,880	—3,030	—3,850	—2,450.00
Onions, unlimed (bushels), .	—33.20	148.53	151.36	143.76	102.61
Onions, limed (bushels), . .	—64.36	—.90	16.35	186.53	34.41

Value of net average increment: unlimed, $26.68; limed, $8.95.
Financial result: unlimed, $20.28 gain; limed, $2.55 gain.

	Results of the Addition of Potash to				
	Nothing.	Nitrate of Soda.	Phosphoric Acid.	Nitrate and Phosphoric Acid.	Average Result.
Scallions, unlimed (pounds), .	−455	−4,585	2,800	4,330	522.50
Scallions, limed (pounds), . .	1,050	1,610	−940	−360	340.00
Onions, unlimed (bushels), .	−26.45	−59.47	158.11	−64.24	1.99
Onions, limed (bushels), . .	257.31	113.72	338.02	301.15	252.55

Value of net average increment: unlimed, $0.52; limed, $65.66.
Financial result: unlimed, $5.88 loss; limed, $59.26 gain.

	Results of the Addition to Nothing of —			
	COMPLETE FERTILIZER.		LAND PLASTER.	
	Unlimed.	Limed.	Unlimed.	Limed.
Onions (bushels per acre), . .	105.96	383.46	−22.59	−80.57
Value of net increment, . . .	$27 55	$99 70	-	-
Value of decrease, ...	-	-	$5 87	$20 95
Financial result, ...	8 35 gain.	80 10 gain.	9 47 loss.	24 55 loss.

The yield upon the limed portion of many of the plots this year is, as was anticipated, much better than last year, although the tops on all parts of the field were somewhat prematurely killed by blight. The heavy application of lime made in that year appears to have corrected in large measure the faulty soil conditions. *We have this year a crop at the rate of nearly* 500 *bushels to the acre of well-cured onions upon the limed half of the plot, which has been yearly manured with nitrate of soda, dissolved bone-black and muriate of potash; while on the unlimed portion of the same plot we have a yield of* 136.9 *bushels to the acre. The lime has evidently proved highly beneficial.*

Particular attention is called to the fact that we nowhere obtained a fairly good crop except upon those plots to which potash has been yearly supplied. The limed portion of the plot, which has yearly been manured with muriate of potash alone, gives a yield at the rate of 383 *bushels to the acre; the nitrate of soda and the potash give a yield at the rate of about* 311 *bushels; the dissolved bone-black and potash, a yield at the rate of* 380 *bushels. These figures make it perfectly evident that potash is an exceedingly important manure*

for the onion crop. Its effects far exceed those of either of the other elements.

Our results make it equally evident that the continuous use of muriate of potash makes the employment of lime an absolute necessity. The combined cost of the muriate of potash and the lime necessarily used with it is likely to be greater than would be the cost of some other source of potash.

That the nitrate of soda as well as the muriate of potash has proven in some degree injurious when used without lime is made equally evident by our results, for the yield on the combined nitrate of soda and muriate of potash without lime is much inferior to the yield on the muriate alone without lime. It is, indeed, almost the poorest in the field.

Especial attention is called to the fact, which was very evident on all the plots where it was used, that dissolved bone-black greatly promoted the perfect ripening of the crop. By far the best ripened crop on the unlimed portion of the field was the crop produced by nitrate of soda and dissolved bone-black. Any other dissolved phosphate would undoubtedly have a similar effect.

Attention is called, further, to the fact that the dissolved bone-black in large measure corrects the injurious effects following the use of muriate of potash. This is made especially evident by the comparison between the yields where dissolved bone-black was used together with nitrate of soda and muriate of potash and where the last two fertilizers were used alone. Where they were used alone, the crop, as has already been pointed out, was almost the poorest in the field, a large share of the plants dying at a very early stage in their growth; while where the dissolved bone-black was used together with these fertilizers a moderate crop was the result. It becomes evident, therefore, that where fertilizers containing a liberal amount of some dissolved phosphate are employed, liming is less necessary than where such phosphates are not employed. That this should be so is not strange, since all dissolved phosphates contain a large amount of sulfate of lime (land plaster), which, if used in large quantities, produces many of the effects ordinarily following the use of lime.

Practical Advice on Fertilizers for Onions.

Although further investigations are called for concerning the many questions connected with using fertilizers for onions, it is believed that the results thus far obtained justify the following advice: —

1. Mixed fertilizers which are to be used for the culture of onions where nothing else is employed should contain about 3 to 4 per cent. nitrogen, 5 to 6 per cent. available phosphoric acid and 8 to 10 per cent. potash. It is believed that the nitrogen of such fertilizers should be derived in about equal proportions from nitrate of soda, dried blood and dry ground fish or tankage. It is further believed that the source of potash should be either the sulfate or carbonate. Such a fertilizer might be required in amounts varying from 1 to 1½ tons.

2. If a home mixture of materials is to be made, it is believed that it should supply 60 pounds of nitrogen, from 90 to 100 pounds of phosphoric acid and 160 to 200 pounds of potash per acre. It is believed, further, that the nitrogen, as stated above, should be derived in part from nitrate of soda and in part from animal materials. It is believed that the phosphoric acid should be derived mainly from acid phosphate or dissolved bone-black, and that for potash either the high or low grade sulphate or the carbonate of potash-magnesia should be employed. As an illustration of a mixture which it is believed will suit average conditions, the following list of materials is given: —

	Pounds.
Nitrate of soda,	200
Dried blood,	250
Dry ground fish or tankage,	200
Acid phosphate,	700
For potash, either of the following: —	
High-grade sulfate,	350
Low-grade sulfate,	700
Carbonate of potash-magnesia,	950

These materials should be mixed just before use, spread after ploughing and harrowed in.

3. It is suggested, the suggestion being based upon our observations, that in case the onions do not ripen well, and where the proportion of scallions is large, the application of lime be tried, or the proportion of acid phosphate increased. If lime is to be used, it is recommended that about 1 ton of quicklime per acre be applied. This should be slaked with water, spread after ploughing, and deeply worked in with wheel harrow. The best season is autumn or very early spring.

"Special" Corn Fertilizer *v.* Fertilizer richer in Potash.

The experiments upon which it is now proposed to comment have for their object the effort to determine the most profitable combination of fertilizers to be used for the growth of corn. The plan of the experiment and the results up to the close of last season are given in full in our last annual report.

Results in recent years had led to the conclusion that this field might be benefited by liming. It accordingly received an application at the rate of 1 ton of air-slaked lime, applied May 14 and thoroughly worked in. The kinds and amounts of fertilizers used during the past season have been somewhat changed. To two of the plots (1 and 3) in the field we have applied materials supplying the same quantity of nitrogen, phosphoric acid and potash as would be furnished by the use of 1,800 pounds of fertilizer, having the average composition of the "special" corn fertilizers analyzed at this experiment station in 1899. This average is as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizers analyzed varied widely in composition, the range for each of the elements being shown by the following: —

	Per Cent.
Nitrogen,	1.5– 3.7
Phosphoric acid,	9.0–13.0
Potash,	1.5– 9.5

The other plots in the field received an application of materials practically the same in kind and quantity as have been recommended in Bulletin No. 58 for corn on soils poor in organic matter. The principal difference between the manuring of these plots and the others is that they receive slightly more nitrogen, much less phosphoric acid and considerably more potash. The materials supplied to the several plots are shown in the following table : —

FERTILIZERS USED.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	-
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

The variety of corn grown this year was Sibley's Pride of the North. The growth was vigorous and healthy, and unaffected, so far as could be seen, by any abnormal conditions. The yields were as follows : —

Yield of Corn, 1900.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1 (lesser potash),	1,510	1,460
Plot 2 (richer in potash),	1,435	1,540
Plot 3 (lesser potash),	1,590	1,675
Plot 4 (richer in potash),	1,515	1,600

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3,	77.50	6,270
Plots 2 and 4,	73.75	6,280

It will be noticed that the yield of grain on the "special" fertilizer exceeds that on the fertilizer richer in potash, the

difference being at the rate of 3.8 bushels per acre; the fertilizer richer in potash gave slightly more stover. The difference in cost of the fertilizers applied on the two sets of plots is at the rate of a little more than $4 per acre. This is the apparent cost of the 3.8 bushels of corn. I say apparent, for the following reason: the field was seeded to mixed grass and clover the latter part of July, and at the present time the condition of plots 2 and 4, which received the fertilizer richer in potash, indicates a much heavier growth of clover next season than on the other plots.

It is believed that when this field is once more broken up and put into corn the yields of plots 2 and 4 will stand relatively better.

In conclusion, attention is called to the fact that the results on this field furnish important light upon the problem as to whether corn can be successfully grown on fertilizers alone. The present is the tenth year since this field has been under experiment, and throughout this time fertilizers only, and in very moderate quantities, have been employed. The result this year on the plots richer in potash is a crop at the rate of about 74 *bushels of sound corn and of* 3 *tons of stover per acre, and a magnificent catch of grass and clover.* The cost of the fertilizers employed this year on these plots is at the rate of $13.50 per acre, not including the lime. One ton of the latter was put on this year, but such application will not be required oftener than once in six or seven years.

Manure alone *v.* Manure and Potash.

This experiment, which was intended to illustrate the relative value in crop production of an average application of manure, as compared with a smaller application of manure used in connection with some form of potash, was begun in 1890. Full accounts of the results in the different years will be found in preceding annual reports, and summaries are found in the reports for 1895 and 1900. The field contains one acre and is divided into four plots of one-fourth acre each. Corn was the crop in 1899. The field was ploughed last fall and seeded to rye for winter protection. After ploughing this spring the field received a dressing of air-slaked lime at

the rate of 1 ton to the acre; this was thoroughly worked in with a wheel harrow; the field was then manured as shown below: —

Plot 1, manure, 1½ cord; weight, 6,805 pounds.
Plot 2, manure, 1 cord; weight, 4,610 pounds; high-grade sulfate of potash, 40 pounds.
Plot 3, manure, 1½ cord; weight, 6,717 pounds.
Plot 4, manure, 1 cord; weight, 4,067 pounds; high-grade sulfate of potash, 40 pounds.

Samples of the manure used were analyzed, and the sulfate of potash was analyzed. The calculated amounts of plant food applied to the several plots are as follows: —

PLOTS.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plot 1,	22.64	19.65	38.43
Plot 2,	14.21	13.70	40.67
Plot 3,	20.15	20.15	27.54
Plot 4,	12.20	12.20	36.67

The variety of corn grown this year was Sibley's Pride of the North. The growth was good and the crop large on all plots. The yield on the several plots is at the rate per acre shown in the following table: —

Yield of Corn (Rate per Acre).

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plot 1,	72.5	6,740
Plot 2,	72.0	7,020
Plot 3,	74.5	6,540
Plot 4,	72.8	6,580

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3, manure alone,	73.5	6,640
Plots 2 and 4, manure and potash,	72.4	6,800

The crops, as in previous years, are of substantially equal value, the manure alone giving 1.1 bushels more grain than manure and potash, while the latter gave 160 pounds more stover. The combination, 4 cords of manure and 160 pounds sulfate of potash per acre, will cost about $6.40 less than 6 cords of manure alone. We have now grown eight corn crops on this field, and the average yields are at the rate per acre for the two manurings: —

Average of Eight Crops.

	Shelled Grain (Bushels).	Stover (Pounds).
Manure alone,	63.0	4,822
Less manure and potash,	58.7	4,497

The money cost of the materials applied to the plots receiving manure and potash for the ten years during which the experiment has continued is at the rate of about $81 less than on the other plots. The manure alone, however, has produced yields exceeding the combination of a smaller amount of manure and potash, at rates per acre amounting to shelled corn 34.4 bushels and stover 2,600 pounds. During two years since the experiment began the field has been in grass, and the yields on manure alone exceed those on manure and potash at rates per acre amounting to hay 2,244 pounds and rowen 1,170 pounds. Such an amount of corn and hay at average prevailing market prices would have been worth about $44.18. In using the large amount of manure alone, then, one would, in effect, allowing the manure to cost $5 to the cord on the land, have expended about $81 for products worth but little more than one-half that sum.

This field has now been seeded to mixed grass and clover seeds. The stand on all plots is good, but the clover is proportionally more abundant on the plots receiving the manure and potash.

It is believed that these experiments conclusively indicate that corn may be more cheaply grown on a combination of manure and potash than on manure alone.

The Relative Value for Green Manuring of the Soy Bean and Cow Peas.

So much has been said concerning the value of cow peas for green manuring purposes that it has seemed desirable to compare this crop with the soy bean for that purpose. Accordingly, two varieties of cow peas, the Wonderful and the Black, the former a late and the latter an early variety, have been grown under conditions allowing comparison with the medium green soy bean. The growth of all the crops was good and each occupied about one-fifth of an acre. The Wonderful cow pea when cut had only just begun to blossom, the Black had but a small proportion of its pods ripe, while all the pods on the soy bean were practically mature. The following table shows the results: —

Cow Peas and Soy Beans for Green Manuring.

VARIETY.	Pounds per Acre.		
	Green Weight.	Dry Matter.	Nitrogen.
Wonderful cow pea,	19,600	3,622	80.4
Black cow pea,	20,035	3,389	62.1
Medium green soy bean,	19,685	5,386	167.3

It will be noticed that the soy bean furnished much larger quantities both of dry matter and of nitrogen than either of the varieties of cow peas. It gave practically three-fifths more dry matter and more than double the nitrogen furnished by the better of the two varieties of cow peas. The roots of the bean were thickly studded with nodules, as also were the roots of the cow peas; and both must, therefore, have possessed the ability to draw upon the atmosphere for a considerable part of their nitrogen. It appears impossible to doubt that the manurial value of the soy beans must have been far greater than that of either of the varieties of cow peas.

In estimating the significance of these results, it should be kept in mind that the soil was a medium loam, retentive of moisture, and that the season had a fairly well-distributed

rainfall. It is not impossible that on lighter and less retentive soils, or with deficient rainfall, the cow pea may compare more favorably with the soy bean as a green manuring crop, for the latter is somewhat impatient of drought and of soils deficient in moisture.

It may be of interest to state in this connection that a portion of the area in soy beans was allowed to ripen, and that the yield was about 36 bushels per acre of thoroughly ripened seed.

Nitrate of Soda for Rowen.

Many experiments both here and elsewhere have convincingly shown the great value of nitrate of soda for application to mowings in early spring. Not many experiments appear to have been tried to determine the effect of such applications for the second crop. Accordingly plots were laid out in July in two of our mowing fields, for the purpose of carrying out an experiment to test this question. There were two sets of these plots. One set included four plots, laid out in a permanent mowing which was seeded twelve years ago, the principal species at the present time being Kentucky blue grass. The first crop was cut June 25. The nitrate of soda was applied July 1 to two plots at the rate of 150 pounds per acre. The first crop of hay on this land was at the rate of 2.16 tons per acre. The rowen was cut on these plots on September 7. The results are shown in the following table: —

Nitrate of Soda for Rowen.

PLOTS.	Pounds per Acre.	
	Nitrate of Soda applied.	Rowen harvested.
Plot 1,	Nothing.	2,082
Plot 2,	150	3,117
Plot 3,	Nothing.	2,438
Plot 4,	150	3,035

The average of plots 1 and 3 is at the rate of 2,260 pounds of rowen per acre; of plots 2 and 4 it is 3,076 pounds per acre. The application, then, of 150 pounds of nitrate of

soda, costing $3, gave an apparent increase of 816 pounds of rowen, at a cost for the fertilizer of .37 cents per pound.

The second set of plots occupied a portion of a field seeded to timothy in 1898. There were eight plots in this series. The first crop of timothy had been cut July 10, and the yield was at the rate of 2.6 tons per acre. The nitrate of soda was applied July 16. The following table shows the nature of the experiment and the results: —

Nitrate of Soda for Rowen.

PLOTS.	POUNDS PER ACRE.	
	Nitrate of Soda applied.	Rowen harvested.
Plot 1,	Nothing.	587
Plot 2,	150	1,394
Plot 3,	Nothing.	514
Plot 4,	150	679
Plot 5,	Nothing.	202
Plot 6,	200	1,137
Plot 7,	Nothing.	440
Plot 8,	250	1,816

The average yield of all the nothing plots was at the rate of 436 pounds per acre. The average of plots 2 and 4 was 1,036 pounds per acre, a gain of 600 pounds of rowen following the application of 150 pounds of nitrate, costing $3, the cost of the gain per pound being .5 cents. The application at the rate of 200 pounds produced an apparent gain of 701 pounds, at a cost of .57 cents per pound; the application at the rate of 250 pounds produced an apparent gain of 1,380 pounds, at a cost of .36 cents per pound; but we have some evidence indicating that this plot is naturally better than the average of the nothings.

In commenting upon these results, it should be stated at the outset that the season was not favorable for the production of a maximum effect from the application of the nitrate, as the rainfall was deficient, amounting, for the entire period during which the rowen upon the old mowing was growing, to 7.26 inches;* during the period that the timothy was growing, to 6.66 inches.† The application of the nitrate produced an effect both upon color and growth almost imme-

* The average for this period for the ten years 1889-98 is 8.59 inches.

† The average for this period for the ten years 1889-98 is 8.39 inches.

diately following the first rain which fell after it had been made. It is believed that the gain in crop would have been much greater had the rainfall been larger.

Further experiment is needed to determine what amount of nitrate, if any, it will pay to use; but the opinion is here advanced that probably the most profitable application will be found not to exceed about 150 pounds per acre.

Experiment in Manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued, with two slight modifications. We have three large plots (between two and one-half and four acres each) under this treatment. According to the system followed, each plot receives wood ashes at the rate of 1 ton per acre one year, the next year ground bone 600 pounds and muriate of potash 200 pounds per acre, and the third year manure at the rate of 8 tons. The changes in manuring introduced this year consist, first, in the use of a small quantity of nitrate of soda in connection with the ashes on one plot and with the ground bone and muriate of potash on another. The experiment is further modified to a slight extent by the fact that a little more than one acre on plot 1, which contains about four acres, was used for experiment in the application of nitrate of soda for rowen, elsewhere described in this report, the nitrate being used at the rate of 150 pounds per acre. Our system of manuring is so planned that each year we have one plot under each of the three manurings. The manure is always applied in the fall, the other materials early in the spring. The ashes were put on this year April 5, the bone and potash April 16. The nitrate of soda was used with the ashes at the rate of 64 pounds to the acre, and was put on April 17. Nitrate of soda was used on plot 3, with bone and potash in the quantities above named, at the rate of 83 pounds per acre. It was applied April 19.

Plot 1, which this year received wood ashes and nitrate of soda, gave a yield at the rate of 2.164 tons of hay and 1.326 tons of rowen per acre. Plot 2, which was top-dressed in the fall of 1899 with manure, yielded hay 1.525 tons and

rowen 1.150 tons per acre. Plot 3, which was manured with a combination of bone and potash in amounts named, and nitrate, gave yields of hay 2.228 tons and rowen (two crops on a part of the plot) 1.219 tons per acre. The average yield of the entire area for this year is 6,510 pounds, hay and rowen both included. The field has now been twelve years in grass, and during the continuance of the present system of manuring, since 1893, has produced an average product, hay and rowen both included, of 6,615 pounds per acre. The plots, when dressed with manure, have averaged 6,817 pounds per acre; when receiving bone and potash, 6,626 pounds; and when receiving ashes, 6,371 pounds. It will be noticed that, while the general average for this year, including all the plots, falls below the general average for the entire period, the average for this year of the two plots receiving bone and potash and ashes is above the general average for the entire period. It will be remembered, however, that these plots have this year, in addition to the usual amounts of bone and potash and ashes respectively, received a light dressing of nitrate of soda. It is possibly this difference in treatment which has produced the results just pointed out.

Poultry Experiments.

The experiments of the past season have, as in previous years, been devoted to the study of methods of feeding, as affecting egg-production. The only experiment the results of which it is proposed to report at the present time is one having for its object the determination of the relative merits of the system of giving a mash in the morning, as compared with the system of giving it late in the afternoon.

General Conditions.

Barred Plymouth Rock pullets, raised on the scattered colony plan, divided into two lots as equally matched in weight and development as possible at the beginning of the experiment, were employed. Twenty such pullets with two cockerels were put into each house. Our houses are detached, and include a closed room for nests and roosts, 10

by 12 feet, with two windows about 3 by 6 feet on the south, scratching shed, 8 by 12 feet, which is left either entirely open in fine weather or closed by folding doors with large glass windows in stormy weather, while the fowls are allowed the run of large yards whenever the weather permits.

Two tests were made: a so-called winter test, December 7 to May 20; and a summer test, May 29 to September 16. The feeds used in the two coops were of the same kinds, the intention being to give each lot of fowls as much food as would be readily consumed. The mash used in these experiments was commonly mixed with boiling water about twelve hours before use, but in some instances was given hot immediately after mixing. The morning mash was always given as soon after light as possible, the evening mash just before dark. The whole grain given to both lots of fowls was scattered in the straw in the scratching shed, for the fowls in one coop early in the morning, for those in the other coop about an hour before dark. Both lots of fowls were given a little millet seed scattered in the straw at noon, the object in view being to keep them industriously searching for food in the straw a considerable share of the time. About twice a week a small cabbage was given to each lot of fowls. The eggs were weighed weekly; all the fowls were weighed at intervals of about one month. Sitters were confined in a coop until broken up, being meanwhile fed like their mates. The prices per hundred weight for feeds upon which financial calculations are based are shown below: —

	Per Cwt.
Wheat,	$1 65
Corn and corn meal,	90
Millet,	1 00
Bran and middlings,	90
Gluten feed,	1 00
Gluten meal,	1 25
Animal scraps,	2 25
Clover,	1 50
Cabbage,	25
Oats,	1 12.5

The health of the fowls under both systems of feeding has been in general good, although, as is usually the case, there have been a few losses. Two fowls on the morning mash died

in April, and post-mortem examination showed a catarrhal condition of the throat and intestines. Three fowls in the evening mash coop died; post-mortem examination of one showing enlarged liver and spleen and ulcerated alimentary canal, and in another case enlarged liver and intestinal parasites.

Winter Experiment.

All details necessary to a full understanding of the experiment will, it is believed, be found in the following tables: —

Foods consumed, Morning v. *Evening Mash, December 7 to May 20.*

KIND OF FOOD.	Morning Mash (Pounds).	Evening Mash (Pounds).
Corn,	261.00	239.50
Wheat,	130.50	120.00
Millet,	39.50	37.75
Bran,	46.00	45.00
Meat scraps,	45.00	43.00
Clover,	22.00	21.50
Corn meal,	112.00	107.00
Cabbage,	62.50	77.75

Average Weights of Fowls (Pounds).

DATES.	MORNING MASH.		EVENING MASH.	
	Hens.	Cocks.	Hens.	Cocks.
December 7,	4.61	7.75	4.33	7.13
February 6,	5.38	7.38	4.78	6.88
March 17,	5.69	7.38	5.28	8.88
May 21,	5.24	7.88	5.13	6.88

Number of Eggs per Month, Morning v. *Evening Mash, Winter Test.*

DATES.	Morning Mash.	Evening Mash.
December,	1	1
January,	19	27
February,	76	52
March,	283	229
April,	271	292
May,	143	157
Totals,	793	758

Morning v. Evening Mash for Egg-production, Winter Test.

	Morning Mash.	Evening Mash.
Total dry matter in foods (pounds),	593.28	556.11
Number of hen days, not including males,	3,228	3,158
Number of hen days, including males,	3,558	3,488
Gross cost of food,	$7 78	$7 36
Gross cost of food per egg (cents),	.97	.97
Gross cost of food per hen day (cents),	.22	.21
Number of eggs per hen day,	.25	.24+
Average weight per egg (ounces),	1.84	1.85
Total weight of eggs (pounds),	91.19	87.64
Dry matter consumed per egg (pounds),	.75	.73+
Nutritive ratio,*	1:6.3+	1:6.1+

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

Summer Experiment.

The method of feeding during the summer experiment was the same as in the winter, save in two particulars: first, in place of cut clover rowen in the mash, lawn clippings in such quantities as the fowls would eat before wilting were fed three times a week, to the hens in all the houses the same; and, second, the feeding of cabbages was discontinued. The yards, 1,200 square feet in area for each house, were kept fresh by frequent turning over of the soil. The tables give all details: —

Foods consumed, Morning Mash v. Evening Mash, May 29 to September 16.

KIND OF FOOD.	Morning Mash (Pounds).	Evening Mash (Pounds).
Bran,	41.80	40.70
Middlings,	41.80	40.70
Meat scraps,	32.00	32.00
Oats,	47.80	49.20
Corn meal,	41.80	40.70
Corn,	171.70	174.80

Average Weight of Fowls (Pounds).

DATES.	Morning Mash.		Evening Mash.	
	Hens.	Cocks.	Hens.	Cocks.
May 29,	5.69	8.00	4.94	6.75
July 30,	5.53	7.75	5.00	6.75
August 16,	5.11	8.00	4.74	7.00

Number of Eggs per Month, Morning v. Evening Mash, Summer Test.

DATES.	Morning Mash.	Evening Mash.
May,	28	24
June,	174	186
July,	163	181
August,	164	128
September,	54	51
Totals,	583	570

Morning v. Evening Mash for Egg-production, Summer Test.

	Morning Mash.	Evening Mash.
Total dry matter in foods (pounds),	337.02	338.11
Number of hen days, not including males,	1,719	1,722
Number of hen days, including males,	1,941	1,944
Gross cost of food,	$3 94	$3 95
Gross cost of food per egg (cents),	.68—	.69+
Gross cost of food per hen day (cents),	.20+	.20+
Number of eggs per hen day,	.34—	.33+
Average weight per egg (ounces),	1.83	1.90
Total weight of eggs (pounds),	66.68	67.69
Dry matter consumed per egg (pounds),	.51—	.59+
Nutritive ratio,*	1 : 5.5+	1 : 5.6

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the total non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

It will be seen that neither in the winter nor summer experiment was there any very considerable difference in the

number of eggs produced. It is, however, possibly significant, and this fact is made evident by the tables showing monthly egg yields, that during the period of shortest days the fowls receiving the evening mash laid less eggs than the others.

The most striking result of the experiments is the great difference in the relative amounts of droppings voided during the night by the fowls under the two systems of feeding. It was noticed from the beginning, and the same remained true throughout the entire period, that the amount of droppings voided during the night by the fowls receiving the evening mash was very much greater than the amount voided by the other lot of fowls. Weights were taken on a number of different occasions, with the results shown below: —

Morning v. Evening Mash.

DATES.	Number of Days Droppings.	Morning Mash.		Evening Mash.	
		Number of Hen Nights.	Weight of Droppings (Pounds).	Number of Hen Nights.	Weight of Droppings (Pounds).
March 3, . . .	1	22	3.00	21	6.00
March 5, . . .	2	44	5.25	42	11.00
March 7, . . .	2	44	5.25	42	10.50
March 10, . . .	1	22	2.50	21	6.25
March 21, . . .	1	22	2.50	19	4.50

It will be noticed that the weight of the droppings voided during the night by the fowls receiving the evening mash during the period of nearly even days and nights during which these weights were taken is practically double the weight of the droppings of the other lot of fowls. The fact thus brought out is doubtless of much significance. It furnishes conclusive evidence that the digestive process in the case of a soft food like a mash is very rapid. The fact that digestion among birds is relatively much more rapid than with most classes of animals has been already many times pointed out. Forbush, in his paper in the report of the secretary of the State Board of Agriculture for 1899, gives valuable data bearing upon this subject concerning a number of the smaller birds and crows. Our experiments indicate that the ordinary domestic fowl, as might have been supposed would be the case, is also

able to digest soft foods with a degree of rapidity which seems astonishing. There has long been a general impression, and the usual practice in feeding fowls is evidence of this, that it is better to give the more solid food at night, especially during the winter, since it will "stay by" the fowls better. Our experiments indicate that this impression is well founded, and that the usual practice is correct, although they cannot be considered to prove it, because, of course, it may be that a period of comparative rest for the digestive organs during the night is better than the condition of more continuous work for these organs which would follow the use of solid food at night.

We have not obtained a sufficient difference in egg-production to be considered significant, but it is believed that the experiment, so far as it goes, indicates that it is better that the mash should be fed in the morning. It is conceivable, however, that, if the mash be given in too large quantities, the fowls will gorge themselves, will then as a consequence become inactive, and remain comparatively inactive during a considerable part of the morning; whereas, if they be given whole grain, for which they are required to scratch, they are of necessity more active. The relative weights of the fowls, particularly during the winter, afford some indication that we to some extent experienced this difficulty; for it will be noticed that the fowls receiving the morning mash, especially during the period of shortest days, weighed considerably more than the fowls receiving the evening mash.

It must, however, be further pointed out that the average difference in weight during the summer months was also considerable, amounting to about one-half pound at the time of each of the weighings. During the earlier part of this period, however, the fowls receiving the evening mash were producing the greater number of eggs, which difference may perhaps account for their decreased relative weight.

It is concluded that, so far as the results of this experiment enable one to judge, the morning mash is preferable to the evening; but it is evident that additional investigation is required in order to throw further light upon the subject.

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